Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

July 14th, 2021

(data current to July 10th – 12th)

Biocomplexity Institute Technical report: TR 2021-077

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About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others

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Overview

- **Goal**: Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

Key Takeaways

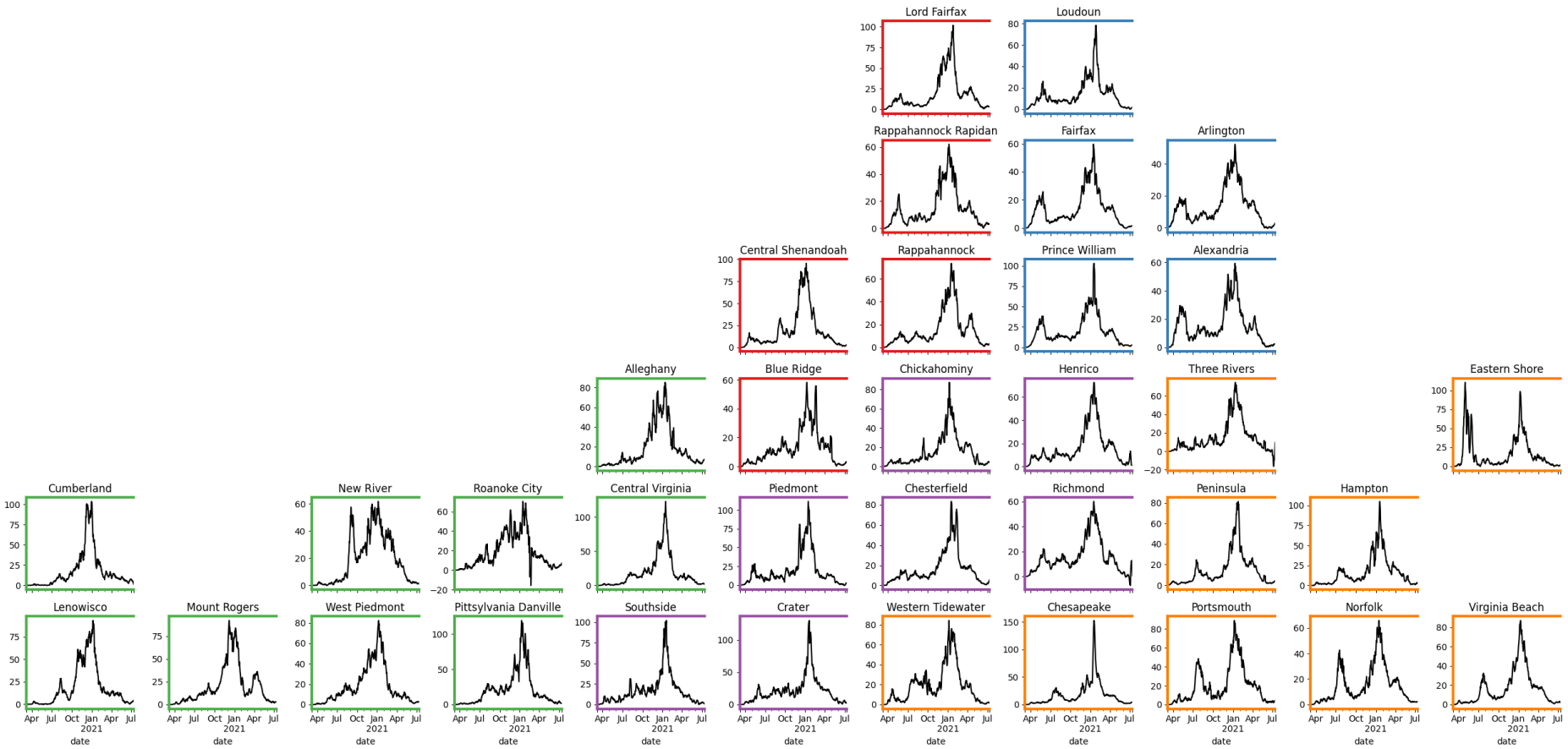
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

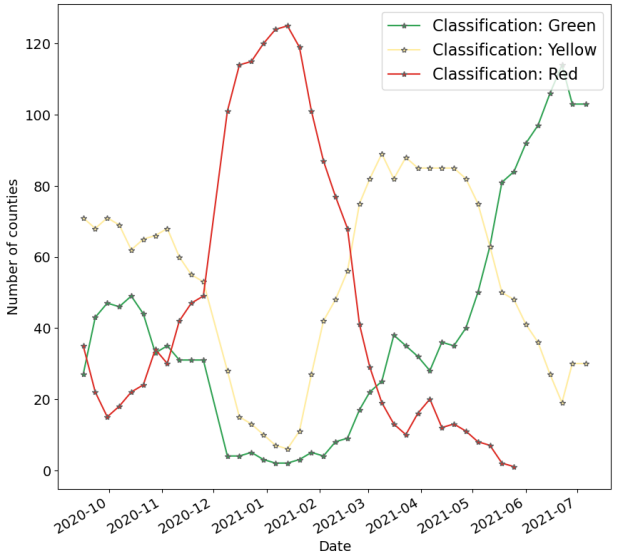
- **Case rates in Virginia have started to rise slightly**
- VA mean weekly incidence up to 3.1/100K from 2.1/100K, US up to 7.2/100K (from 4.2/100K)
- Fewer zip codes in Virginia (57%, 511 of 896 zips) had zero cases this past week (down from 63%)
- Vaccination acceptance remains among unvaccinated larger in some regions than others
- Projections show uptick in activity, with larger growth possible fueled by Delta's increasing prevalence
- Recent updates:
  - Delta variant dominates and has impacts on severity of disease
  - Study scenarios: Fall resurgence and Fatigued control spike in summer
  - Limited waning of natural immunity included in fit and projections, also with seroprevalence update

The situation continues to change. Models continue to be updated regularly.

Situation Assessment

Case Rates (per 100k) and Test Positivity





https://data.cms.gov/stories/s/q5r5-gjyu

County level test positivity from RT-PCR tests.

Green: <5.0%
(or with <20 tests in past 14 days)

Yellow: 5.0%-10.0%
(or with <500 tests and <2000 tests/100k and >10% positivity over 14 days

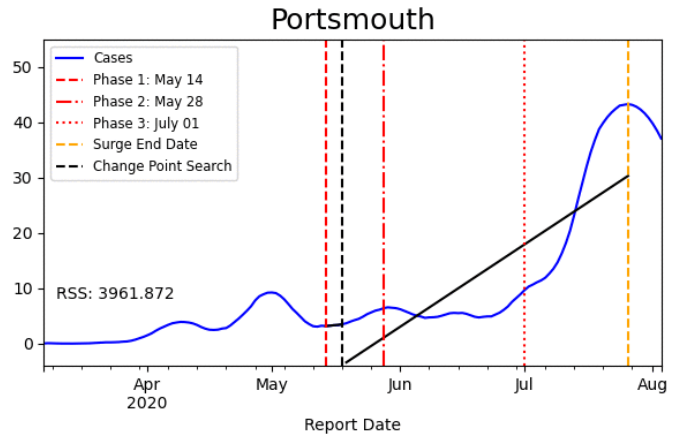
Red: >10.0%
(and not "Green" or "Yellow")

District Trajectories

Goal: Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

Method: Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

Hockey stick fit

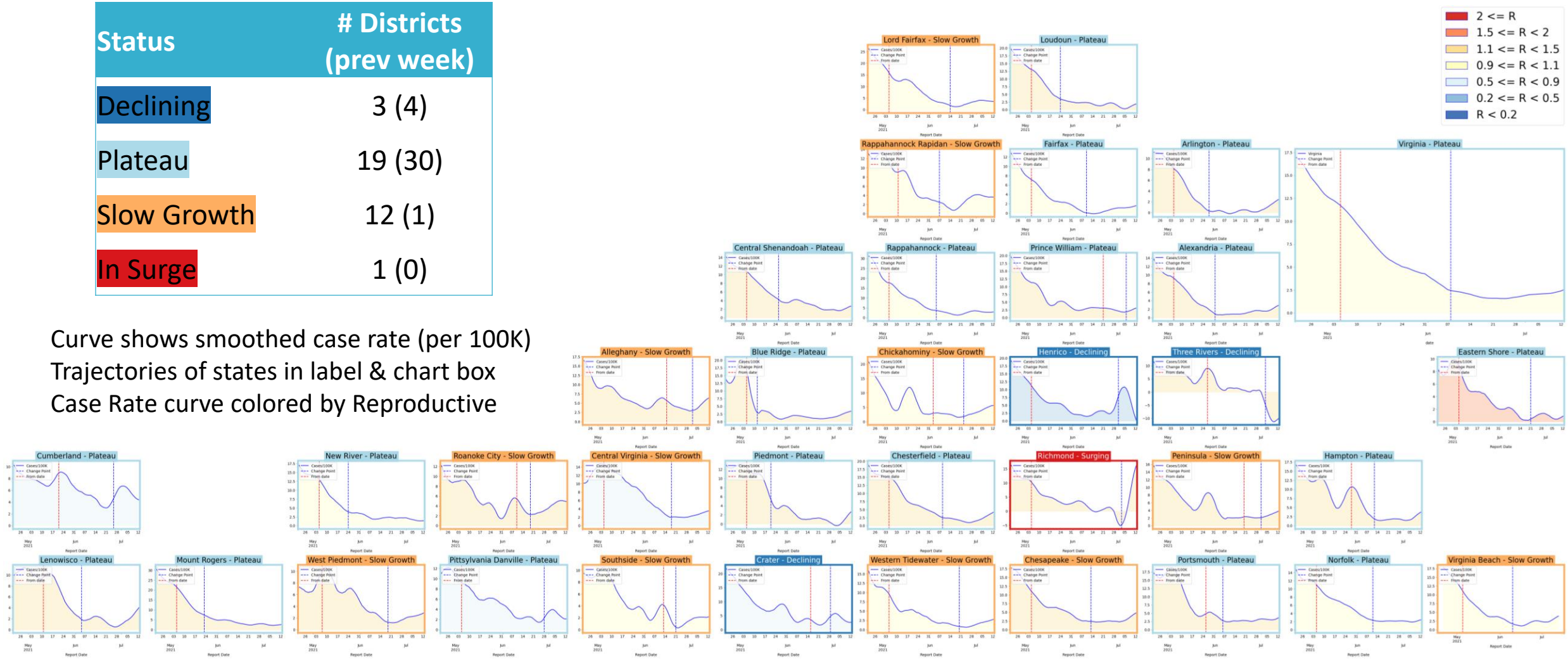


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	3 (4)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	19 (30)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	12 (1)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	1 (0)

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	3 (4)
Plateau	19 (30)
Slow Growth	12 (1)
In Surge	1 (0)

Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive



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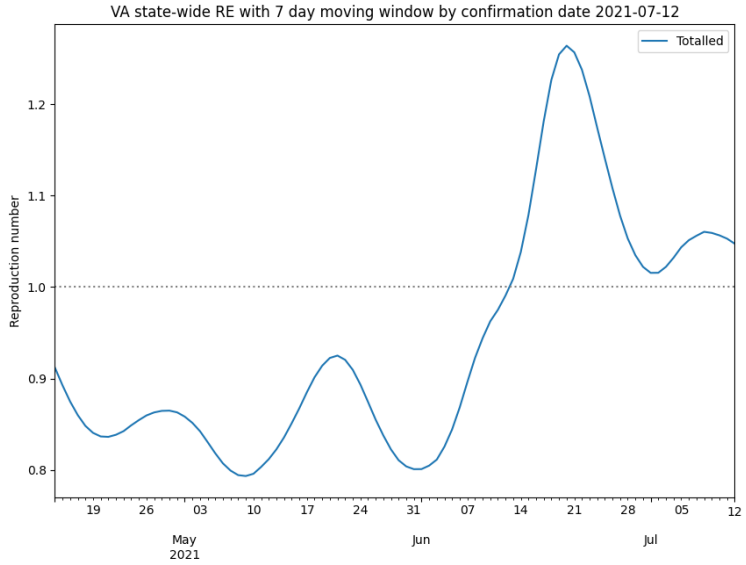
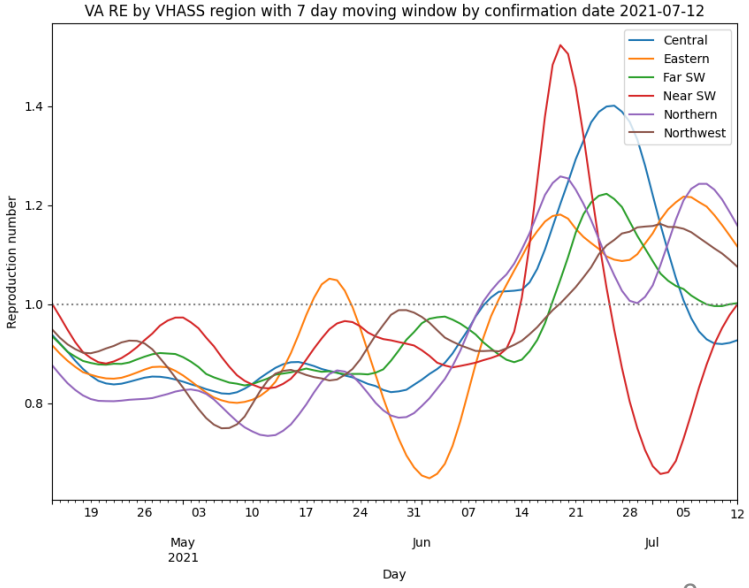
Estimating Daily Reproductive Number

July 12th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	1.047	0.185
Central	0.927	-0.164
Eastern	1.116	0.174
Far SW	1.002	0.033
Near SW	1.000	0.601
Northern	1.159	0.344
Northwest	1.075	0.073



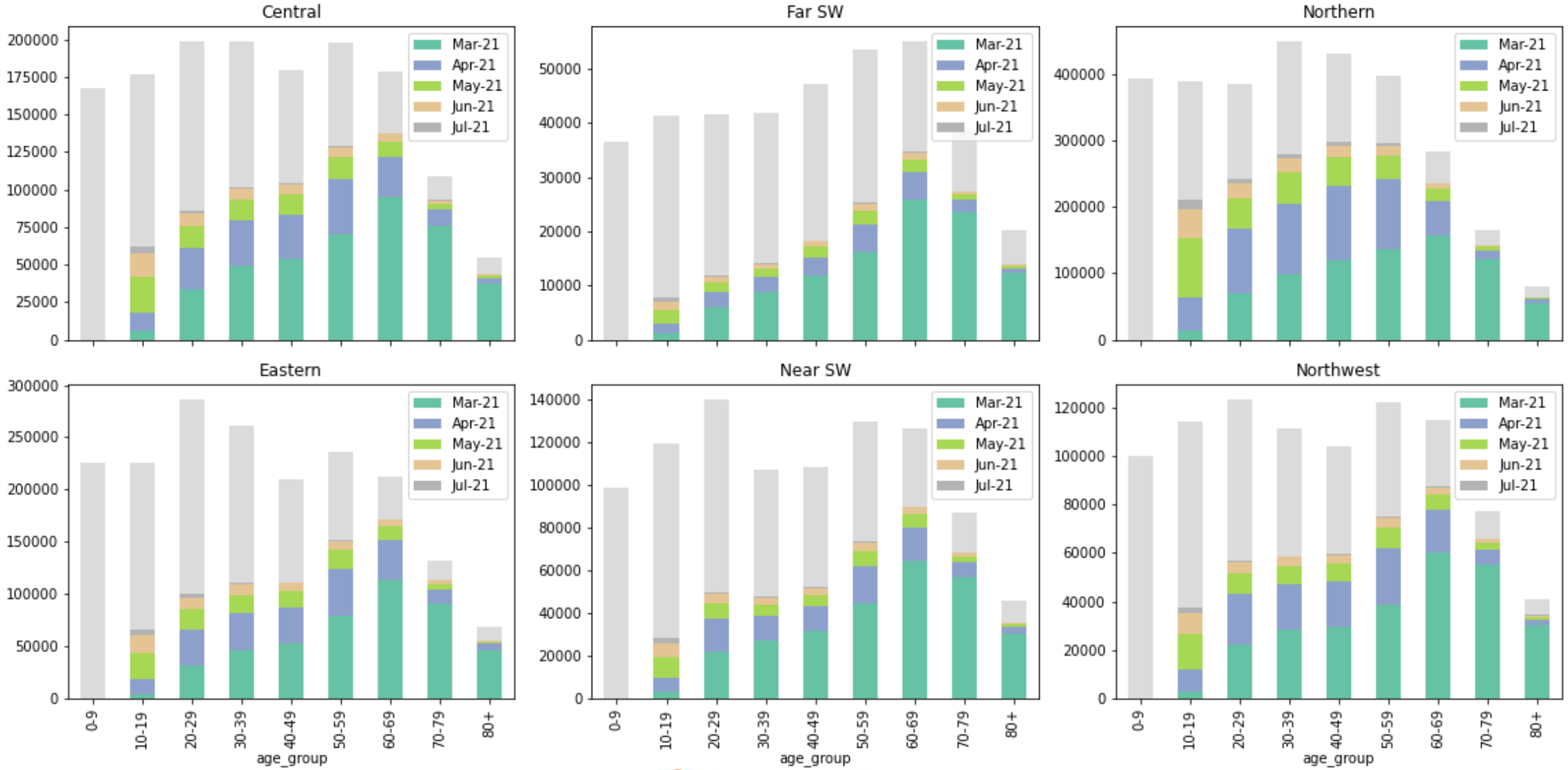


Methodology

- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Vaccinations Shift to Younger Populations



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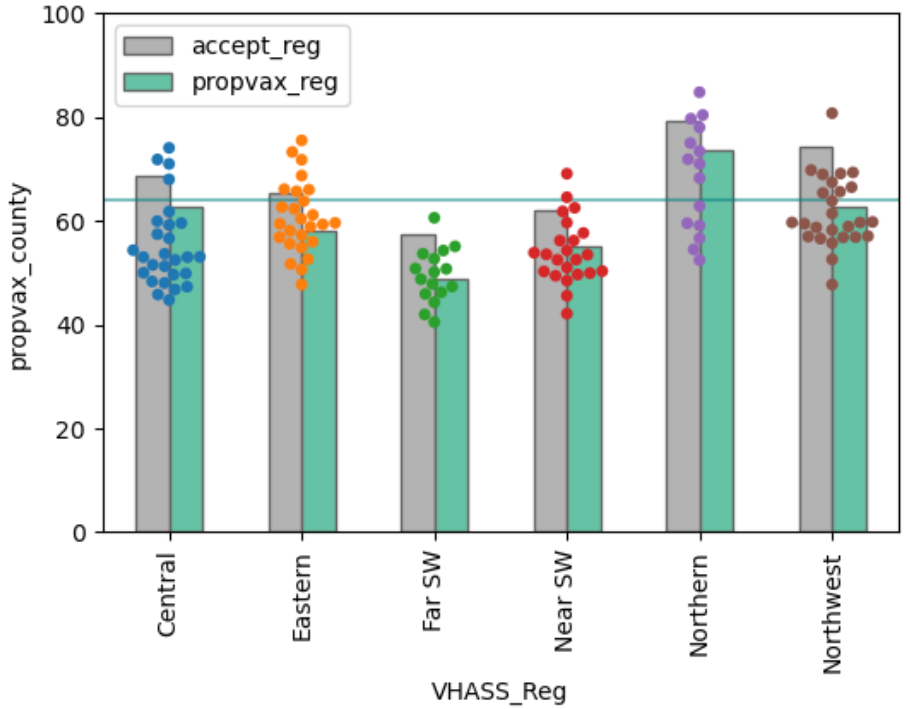
Vaccination Acceptance by Region

Corrections to surveys:

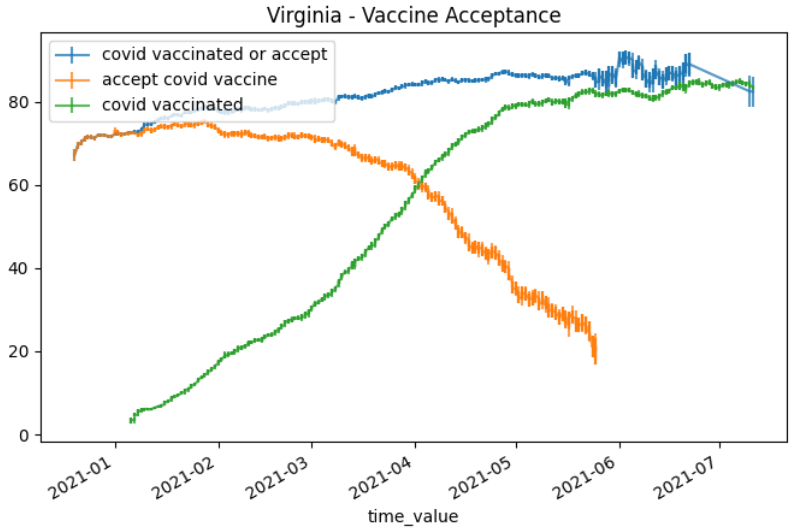
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at the state level and corrected in same manner

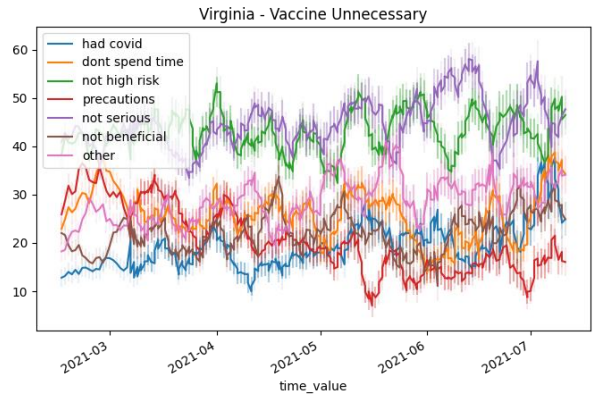
Region	COVIDcast accepting corrected	VDH proportion vaccinated
Central	71%	62%
Eastern	68%	57%
Far SW	49%	49%
Near SW	63%	55%
Northern	79%	73%
Northwest	69%	62%
Virginia	**72%**	**63%**



Grey Bar: Survey measured and corrected acceptance
Green Bar: Proportion of eligible population administered a vaccine
Dots: Proportion administered at least one dose for each county

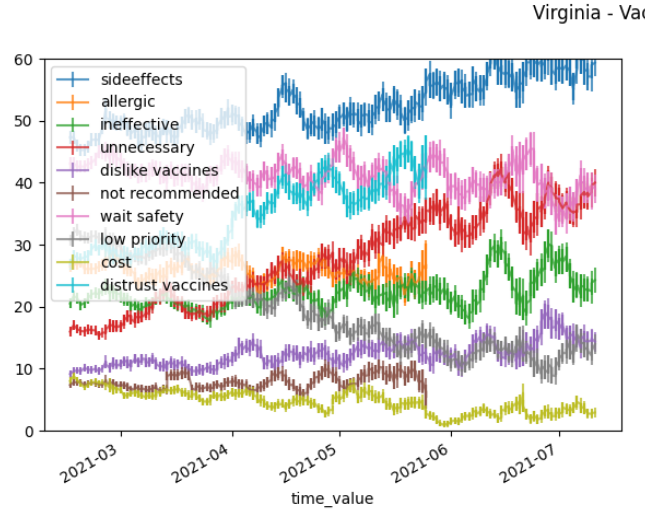
Vaccine Acceptance in Virginia - COVIDcast

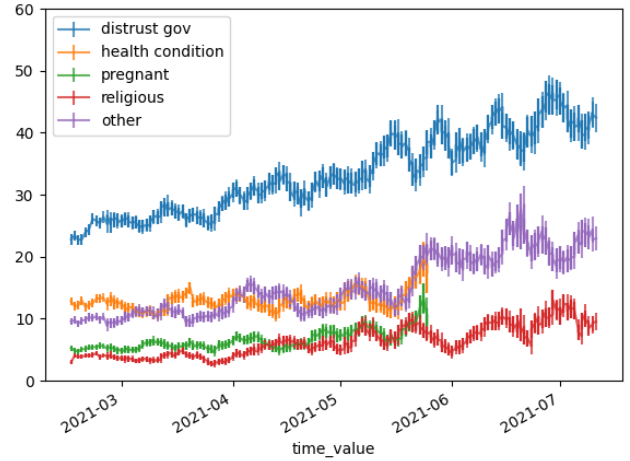




Acceptance remains high:

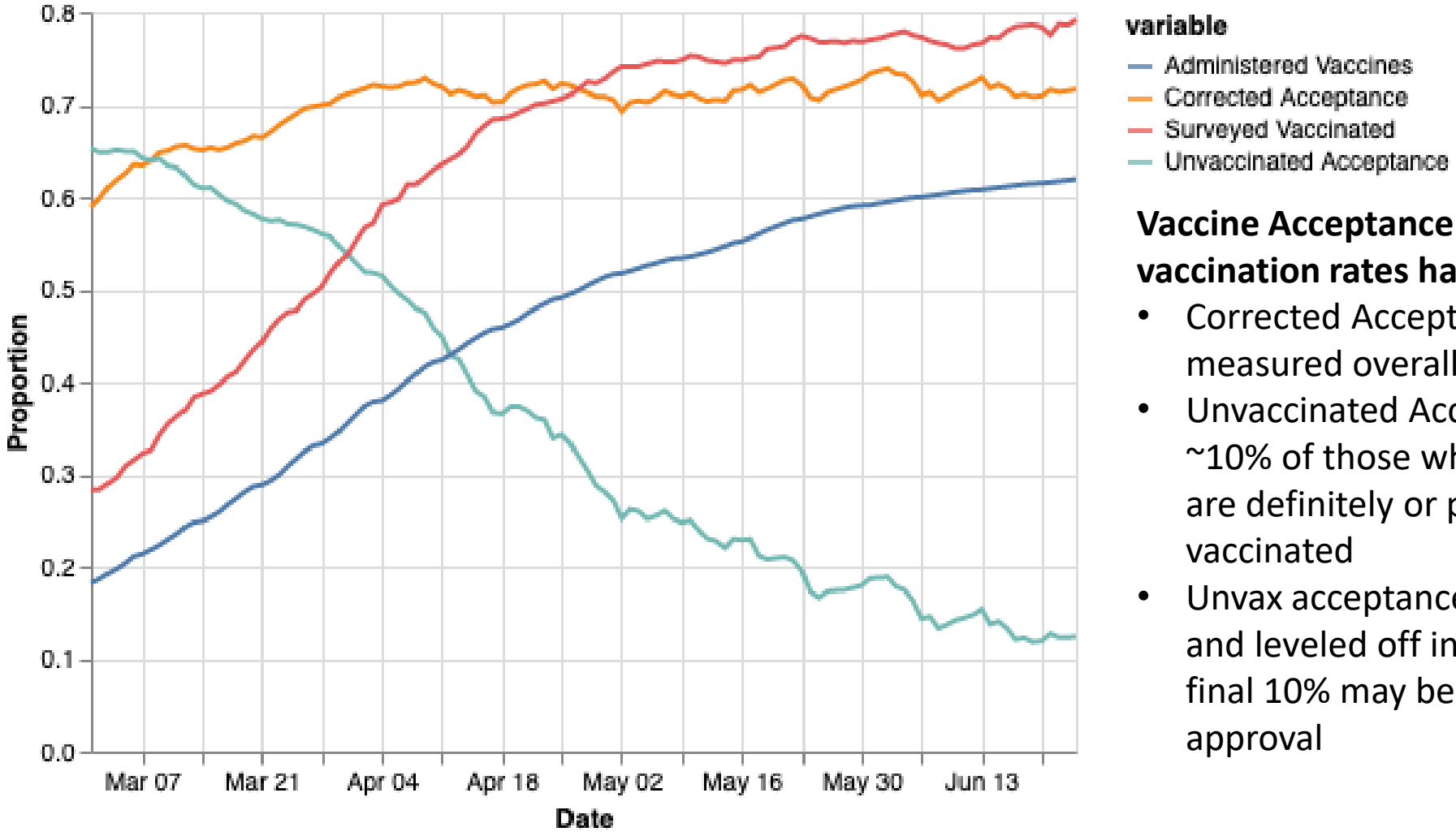
- Proportion of Virginians that have already or would definitely or probably accept vaccination if offered today
- *Survey respondents are reporting high levels of vaccination of ~80% reflecting bias of the mechanism*
- **Top reasons for hesitancy**: side effects, distrust (increasing), unnecessary (increasing)
- **More likely to take if recommended by:** doctors and friends
- **Reasons unnecessary**: Not serious, not high risk, or other





Data Source: https://covidcast.cmu.edu

Vaccine Acceptance Components over Time



Vaccine Acceptance has risen as vaccination rates have climbed

- Corrected Acceptance reflects the daily measured overall acceptance
- Unvaccinated Acceptance shows still ~10% of those who are unvaccinated are definitely or probably willing to be vaccinated
- Unvax acceptance has declined a bit and leveled off in last couple of weeks, final 10% may be waiting for FDA approval

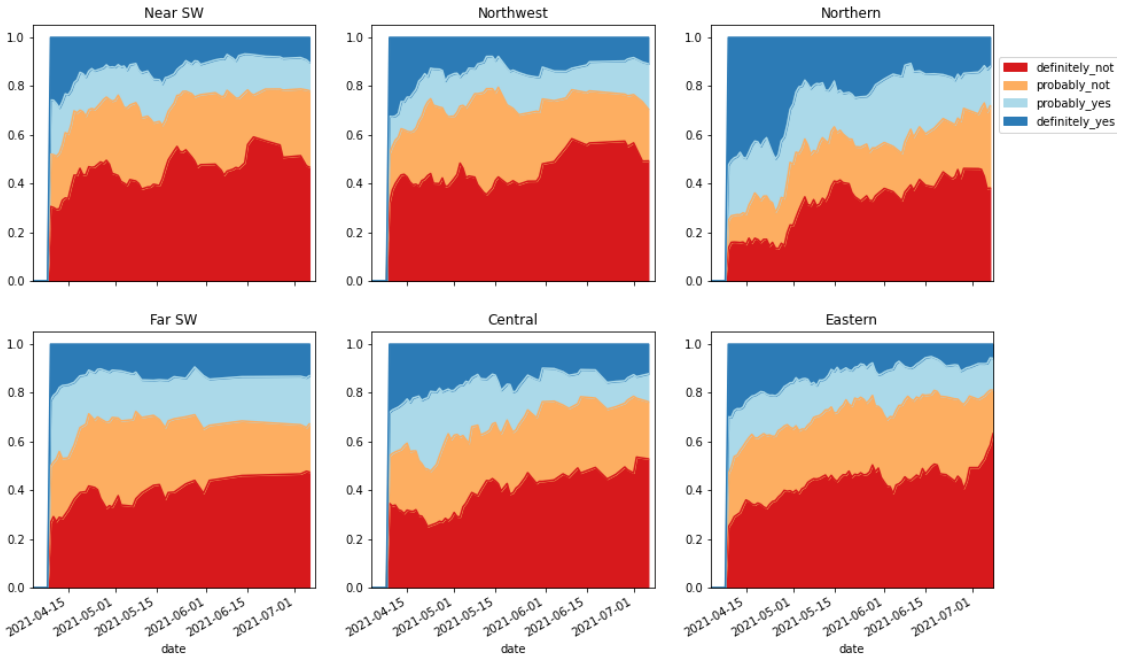
Data Source: https://covidcast.cmu.edu

Vaccine Acceptance by Region- COVIDcast

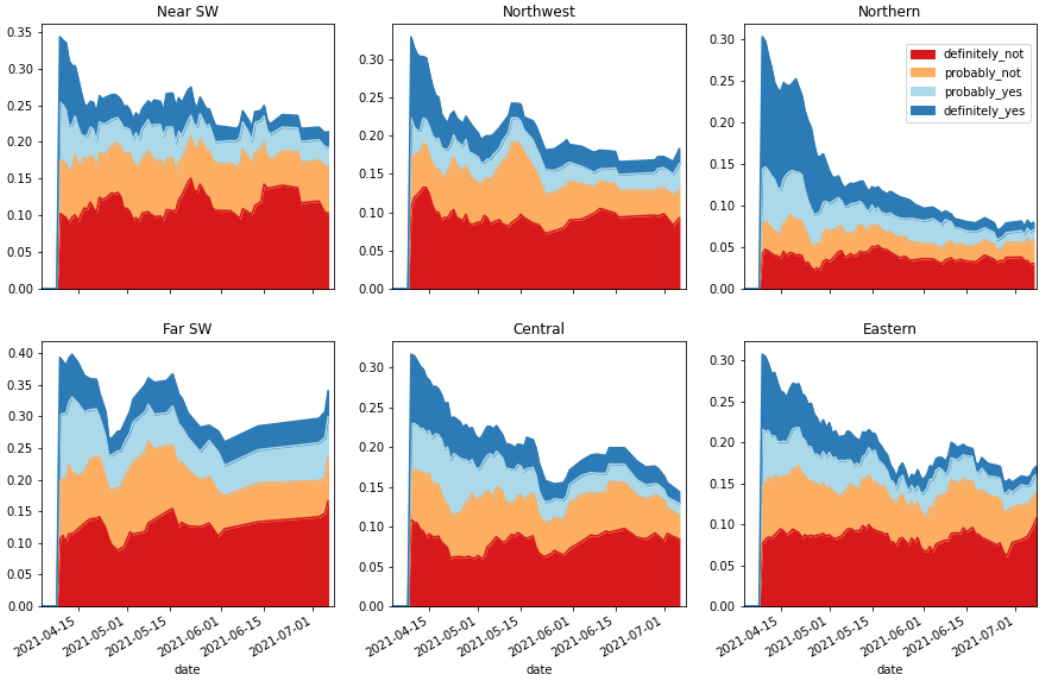
Levels of Acceptance and potential acceptance in flux:

- Nearly all the “Definitely Yes” have been vaccinated, yet there are 10-15% remaining across the regions
- Northwest and Southwest (to lesser degree) see growth in “probably not”, seemingly from “definitely not”

Unvaccinated Only



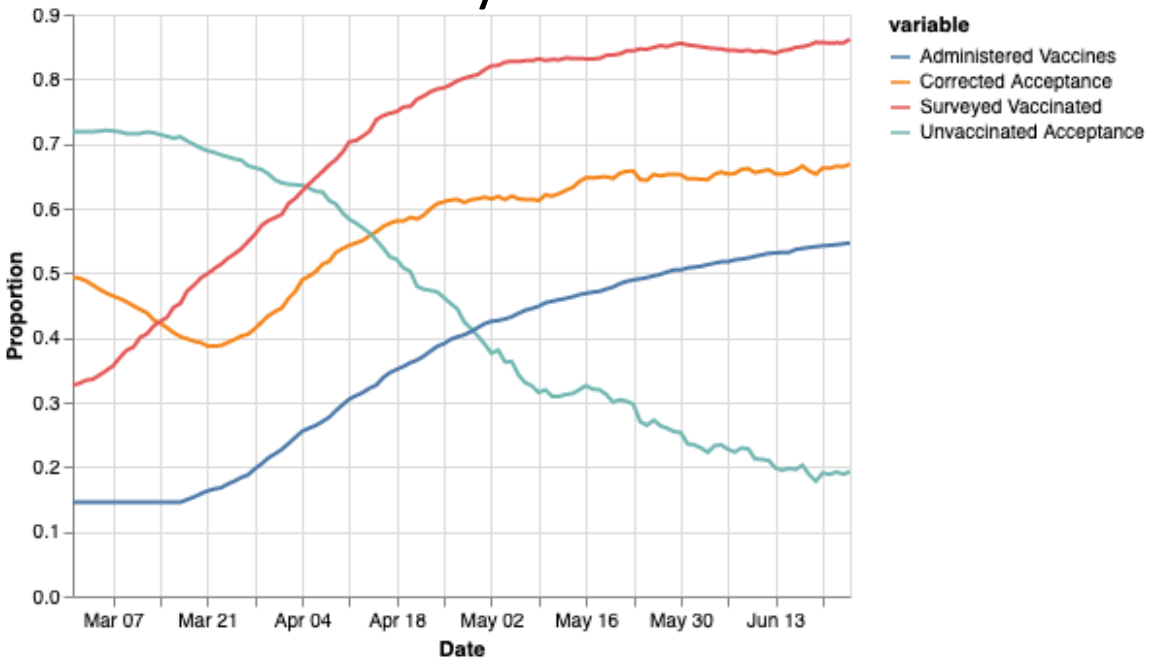
All Respondents



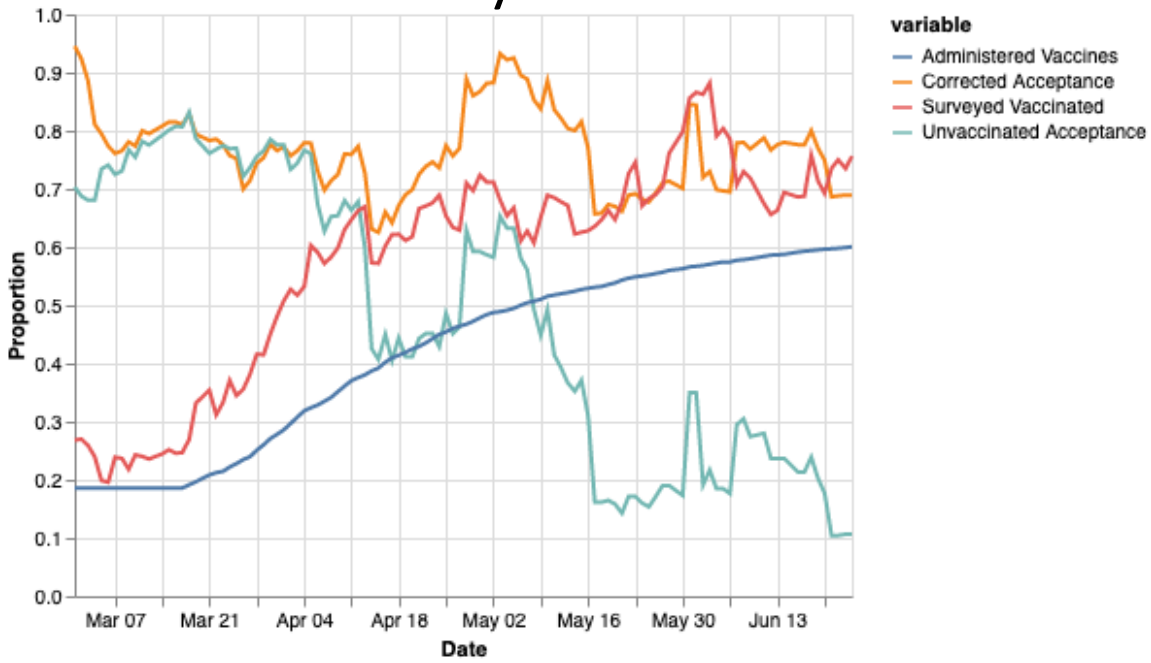
Data Source: https://covidcast.cmu.edu

Vaccine Acceptance by Age Group

25-34 year olds



35-44 year olds



Vaccine Acceptance Components over time for Younger Adults (25-34 and 35-44 year olds)

- Limited response rate for over 45 age groups
- Corrected Acceptance for younger adults is a little lower than the overall population
- Slight trend upward in past 3 months for 25-34, but 35-44 has remained relatively stable
- Around 20% of unvaccinated in these age-groups remain accepting but unvaccinated

Data Source: https://covidcast.cmu.edu

SARS-CoV2 Variants of Concern

Emerging new variants will alter the future trajectories of pandemic and have implications for future control

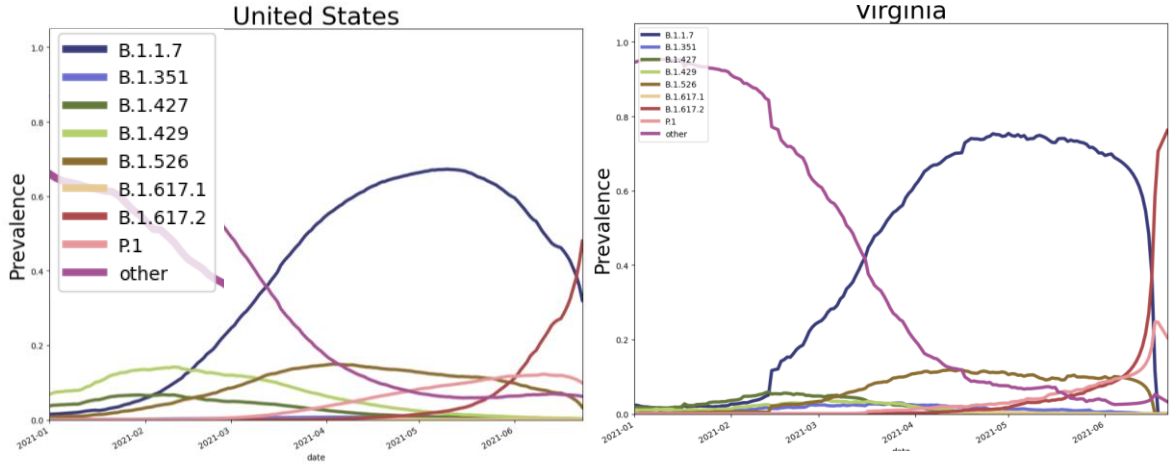
- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations
- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future

	New WHO Name	Transmissibility	Immune Evasiveness	Vaccine Effectiveness^
Ancestral		—	—	✓
D614G		+	—	✓
B.1.1.7	Alpha	+++	—	✓
B.1.351	Beta	+	++++	✓
P.1	Gamma	++	++	✓
B.1.429	Epsilon	+	+	✓
B.1.526	Iota	+	+	✓
B.1.617.2	Delta	++++*	++#	✓

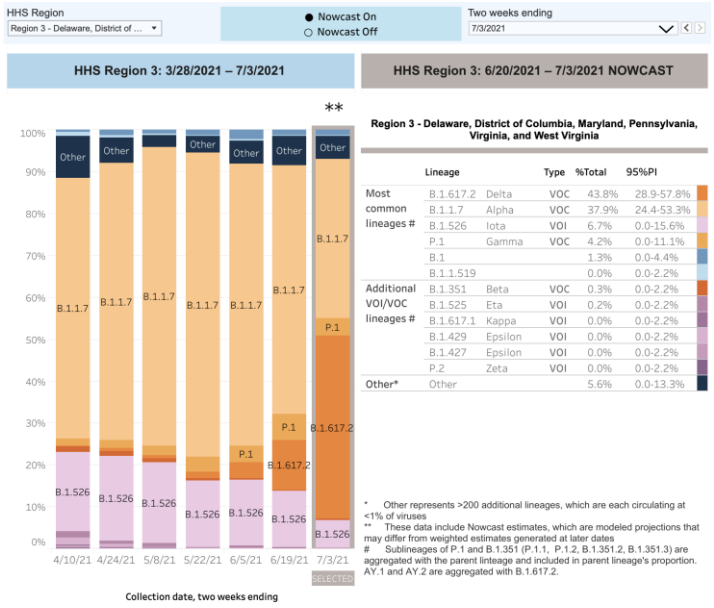
*Relative transmissibility to B.1.1.7 yet to be fully defined
^Effectiveness from real world evidence vs. severe illness, not all vaccines are effective vs all variants, and importance of 2-doses, especially for B.1.617.2 for which 1 dose of mRNA or AZ is only ~30% effective # May carry more immune escape than P.1, to be determined

World Health Organization

WHO and Eric Topol



GISAID outbreak.info Outbreak Info



CDC Variant Tracking

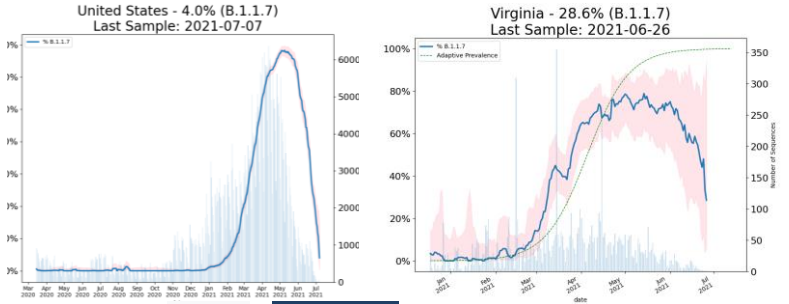
SARS-CoV2 Variants of Concern

Alpha α - Lineage B.1.1.7

Prevalence: Levels have stalled and are now dropping in most states; flat in VA

Transmissibility: Estimated increase of 50% compared to previous variants. B.1.1.7's mutations boost its overall levels of viremia; study from Public Health England shows contacts of B.1.1.7 cases are more likely (50%) to test positive

Severity: Increased risk of hospitalization (60%) and mortality (60%). Danish study shows B.1.1.7 to have a 64% higher risk of hospitalization, while Public Health Scotland studies showed a range of 40% to 60%; Study in Nature estimates 60% higher mortality

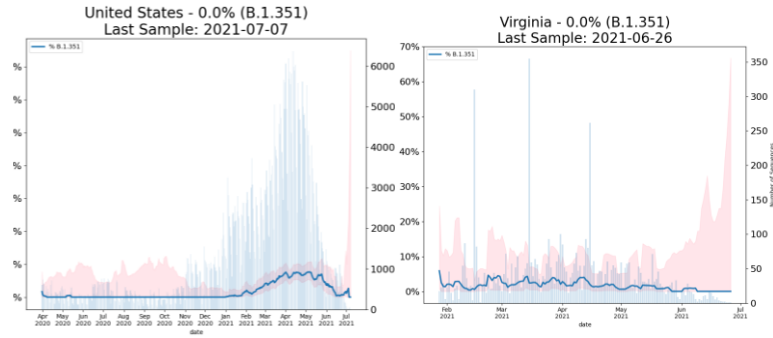


GISAID outbreak.info Outbreak Info

Beta β - Lineage B.1.351

Prevalence: Levels have remained low, as this variant's transmissibility can't compete with B.1.1.7, however, as more of the population becomes immune it may gain an advantage

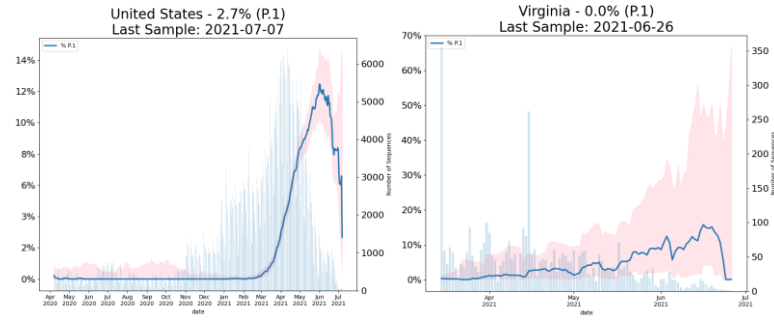
Immune Escape: Many studies show that convalescent sera from previously infected individuals does not neutralize B.1.351 virus well which is predictive of protection, however, vaccine induced immunity shows signs of effectiveness



Gamma γ - Lineage P.1

Prevalence: Nationally at 10%, slow increase in VA at 9%

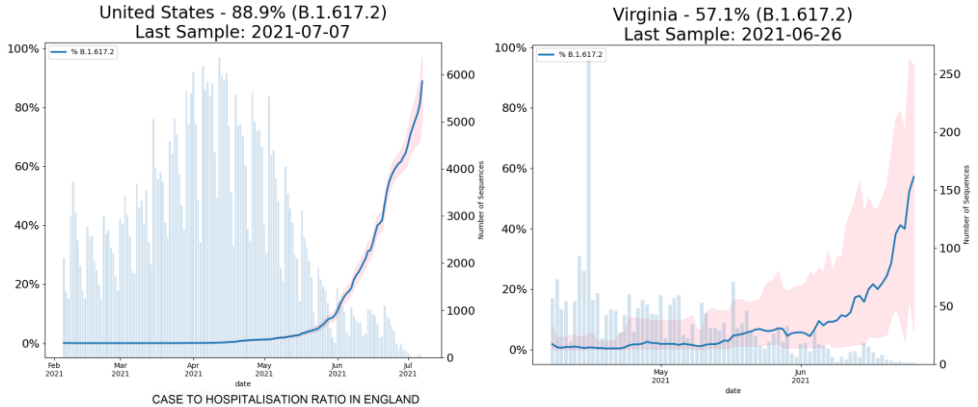
Study estimates 17-32% of all infections in Manaus in 2021 were reinfections, which helps explain data from Brazil demonstrating P.1's continued dominance in Rio despite presence of B.1.1.7

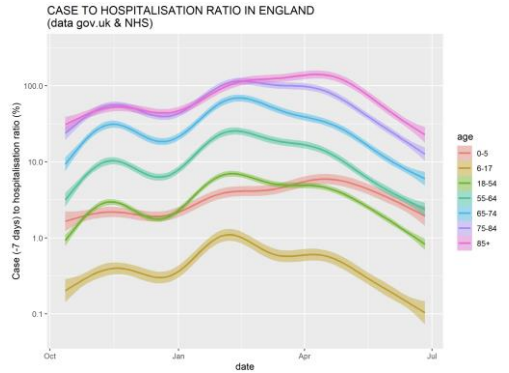


SARS-CoV2 Variants of Concern

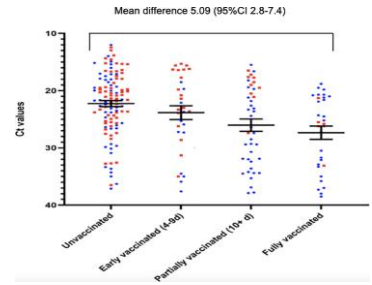
Delta δ - Lineage B.1.617.2 and related subvariants

- Delta plus δ+ lineage which contains the K417N mutation is emerging as a sub-variant that is even more transmissible. Declared a VoC in India
- Strain shows continued growth in Europe and across US, predicted to predominate in coming weeks (July 2nd in VA), Scotland now experiencing highest daily case counts, driven by Delta
- More reports describe time Delta variant escapes vaccine immunity, with recent Israeli study showing a 64% efficacy against infection, however, remains highly effective against hospitalization and death
- In the UK the hospitalization to case ratio declines over all age groups. Despite Delta's increased severity, the UK has lower hospitalizations and deaths with Delta dominating than previously experienced with Alpha
- Public Health Scotland study in Lancet suggests Delta is 2x more likely to cause hospitalization than Alpha
- Recent Lancet study shows vaccinations continue to show reduced infectiousness even in breakthrough cases

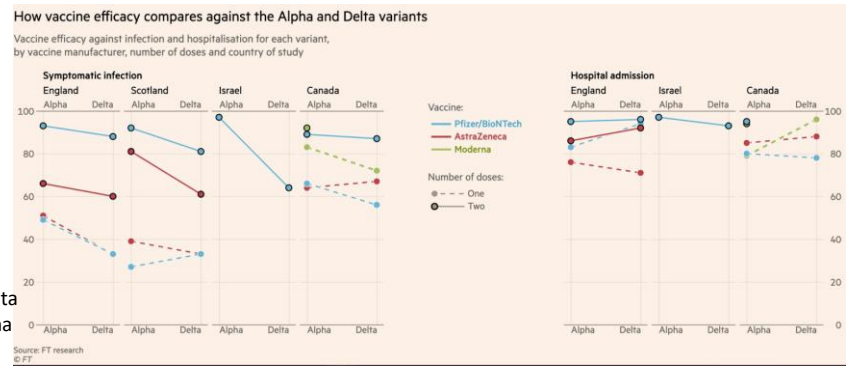




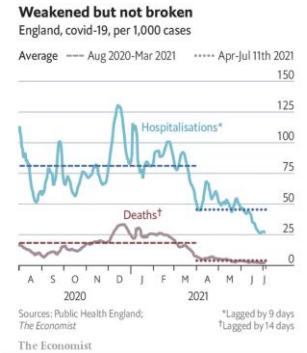
In the UK the case to hospitalization ratio continues to decline despite the rise of Delta Twitter



More vaccine lower levels of virus, which infers less infectivity Lancet Regional Health - Europe

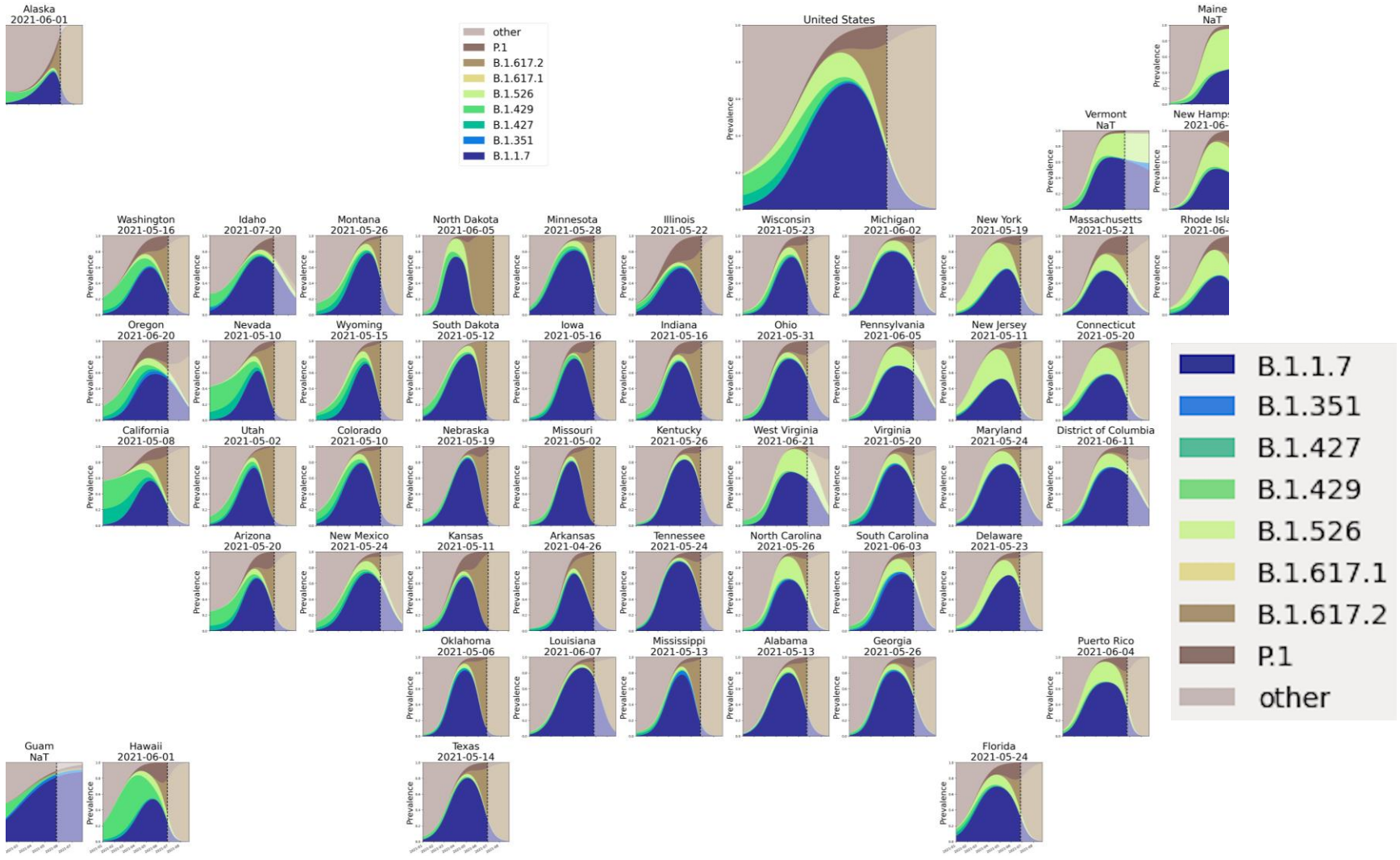


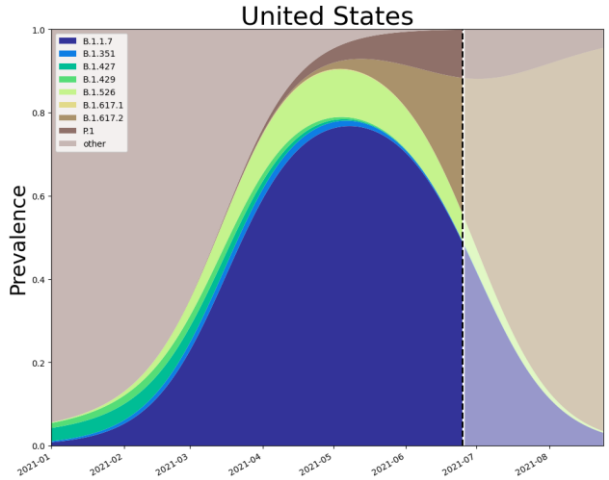
Vaccines less effective against infection with Delta compared to Alpha Financial Times

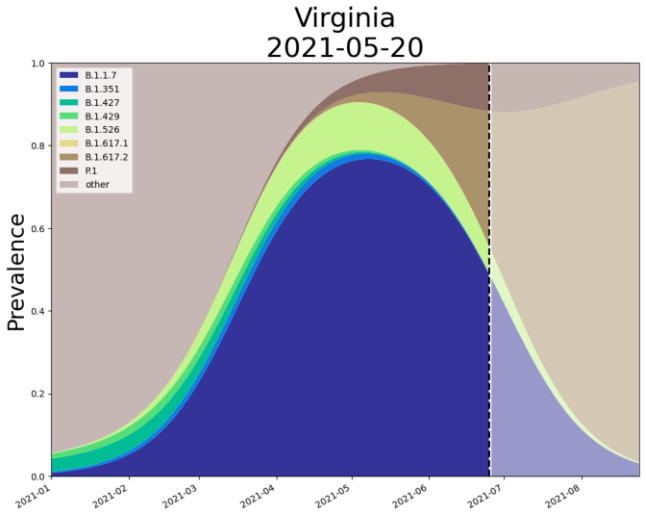


While Delta escaped immunity, there is more immunity around thus severe covid is more rare than with alpha The Economist

Variant of Concern Trajectories

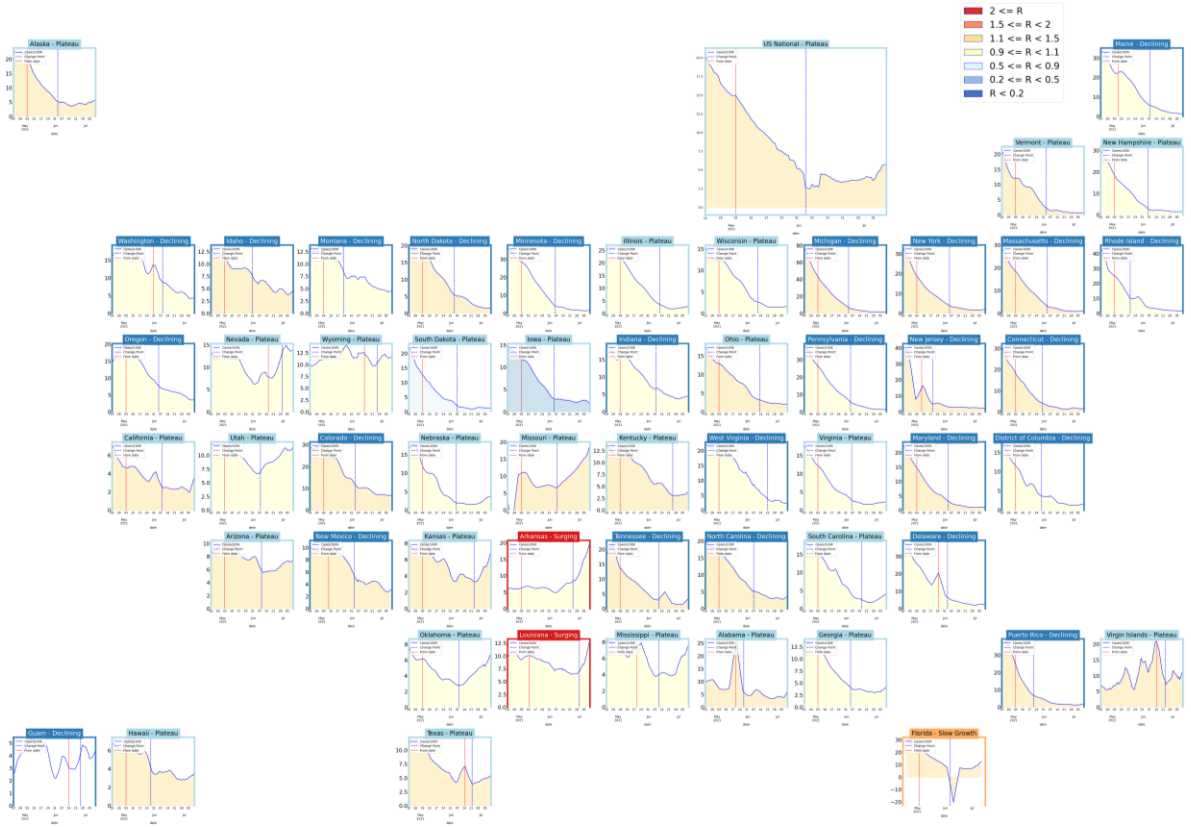






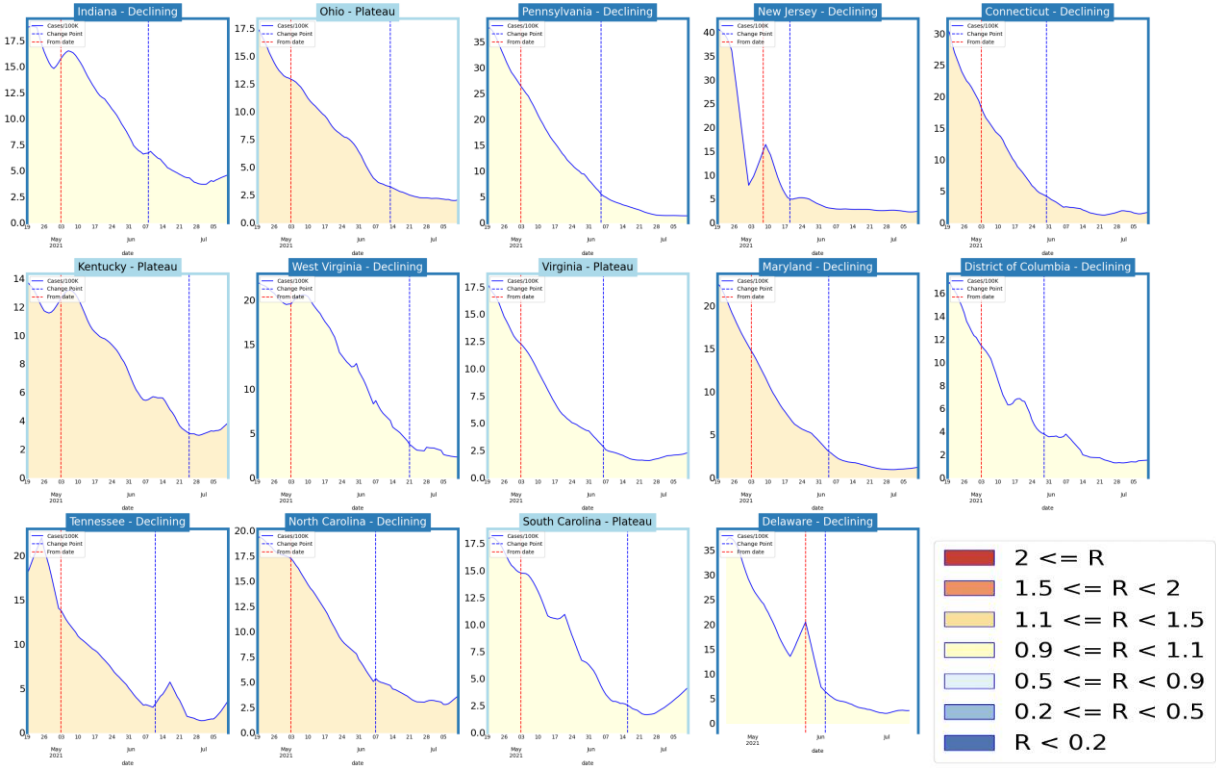
Other State Comparisons

Trajectories of States



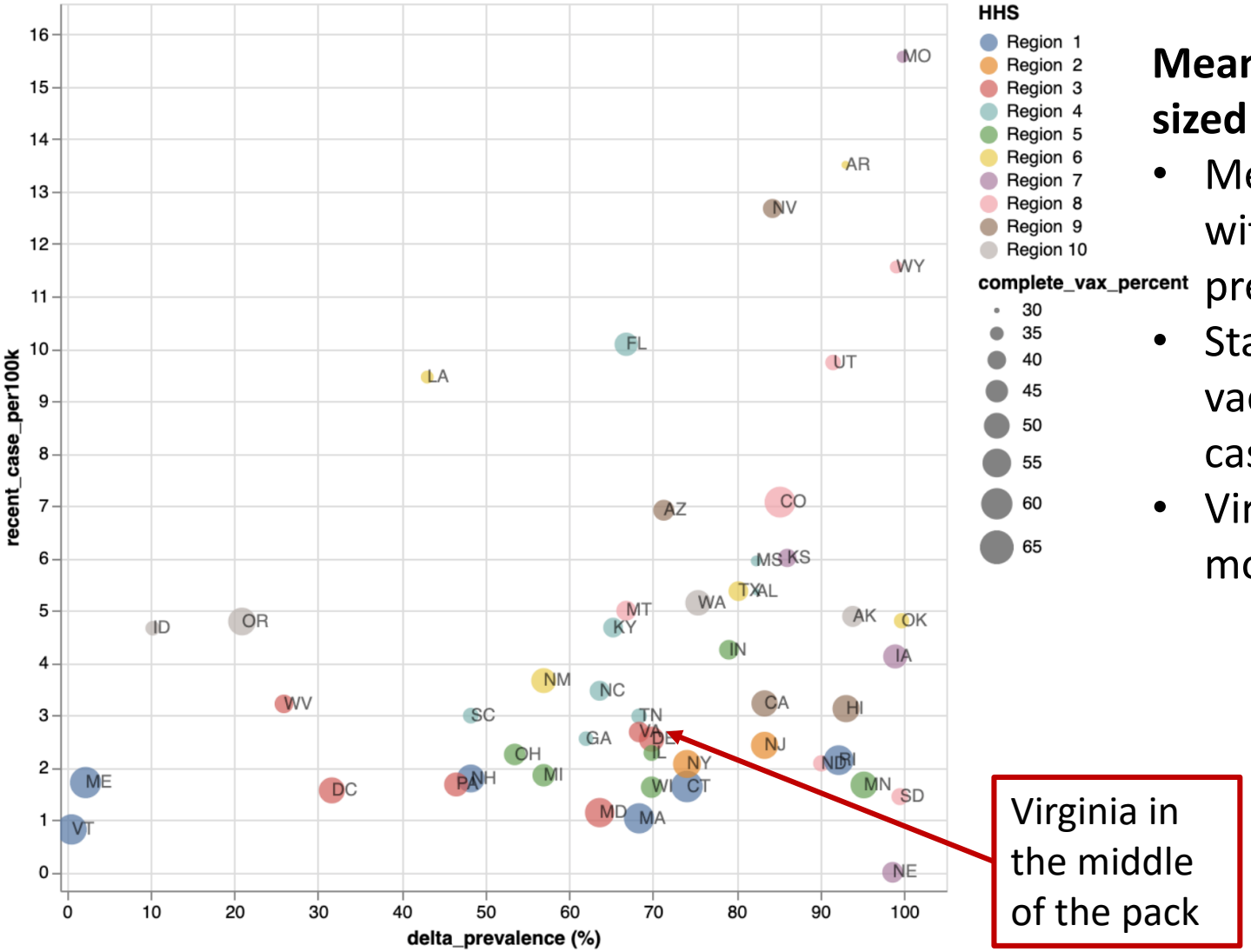
- More states showing some activity with surges in the plains and southern Midwest
- States with low vaccination rates and high Delta show most activity

Virginia and her neighbors



- VA and neighbors mostly show minimal growth or maintain their plateaus

Recent Cases Correlate with Delta and Low Vax



Mean cases per 100K vs. Delta prevalence, sized by vaccine coverage

- Mean case rate in last month correlates with the current levels of Delta prevalence
- States with smaller "size" are least vaccinated and most susceptible to high case rates
- Virginia currently low case rate despite moderate delta prevalence

Virginia in the middle of the pack

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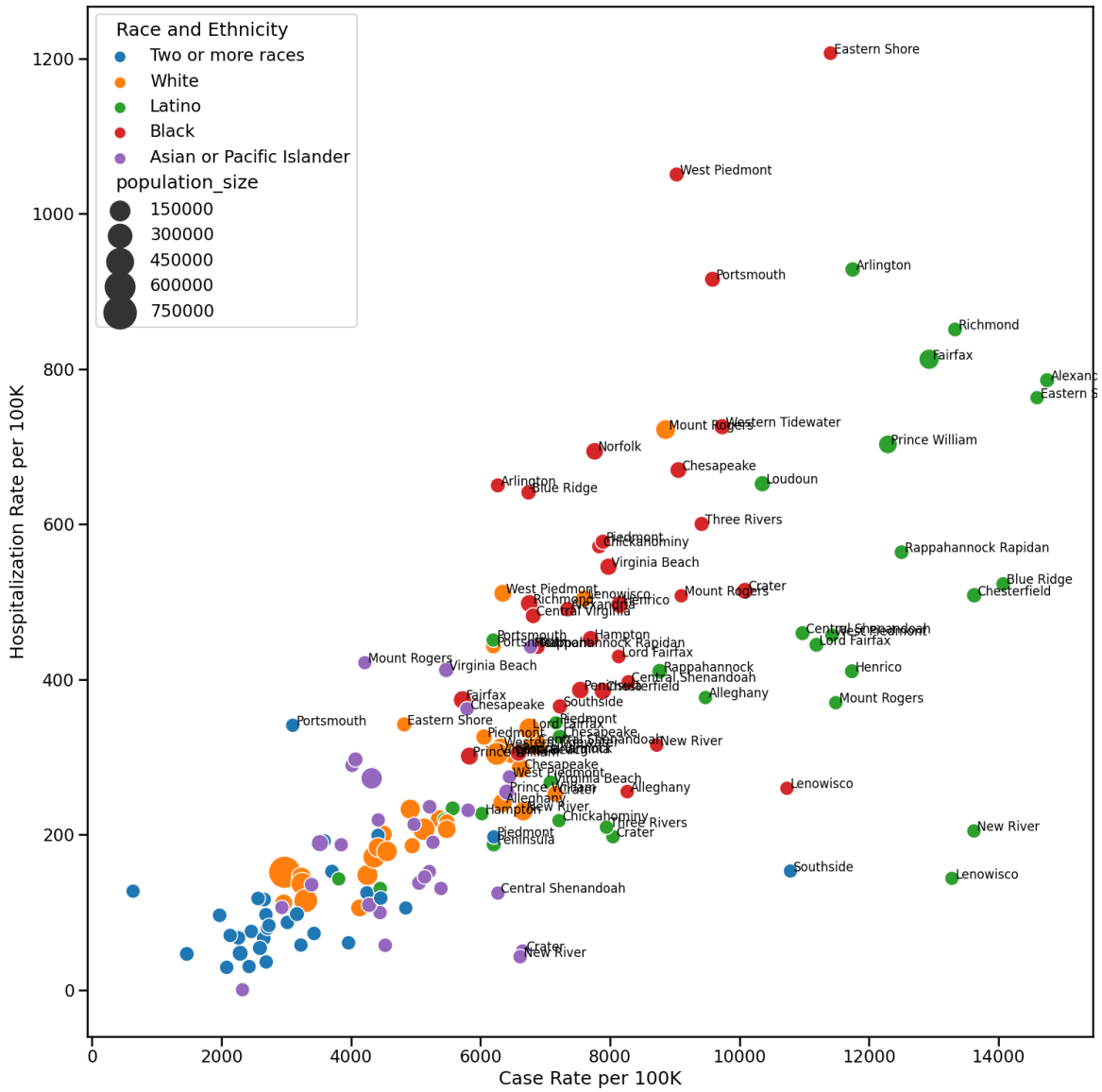
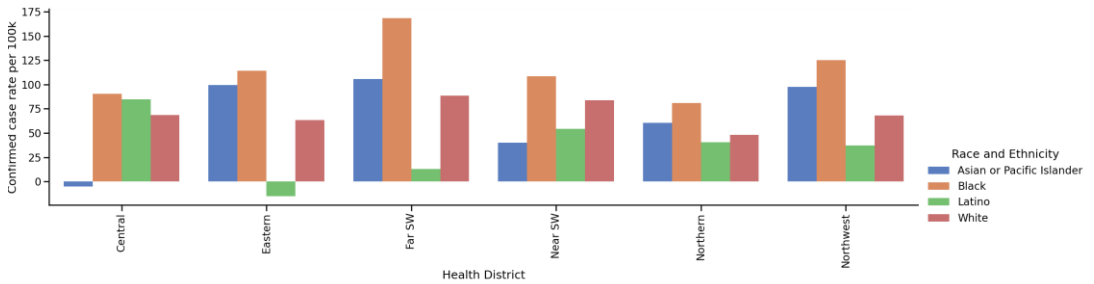
Race and Ethnicity cases per 100K



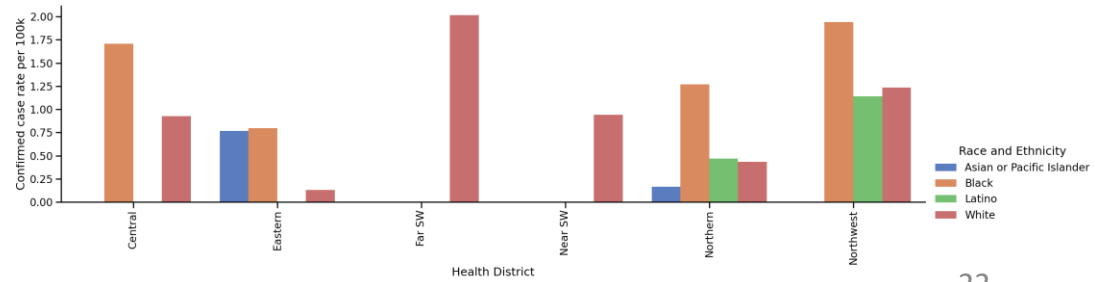
Rates per 100K of each Racial-Ethnic population

- Each Health District's Racial-Ethnic population is plotted by their Hospitalization and Case Rate
- Points are sized based on their overall population size (overlapping labels removed)
- Change in rates over the last 2 weeks

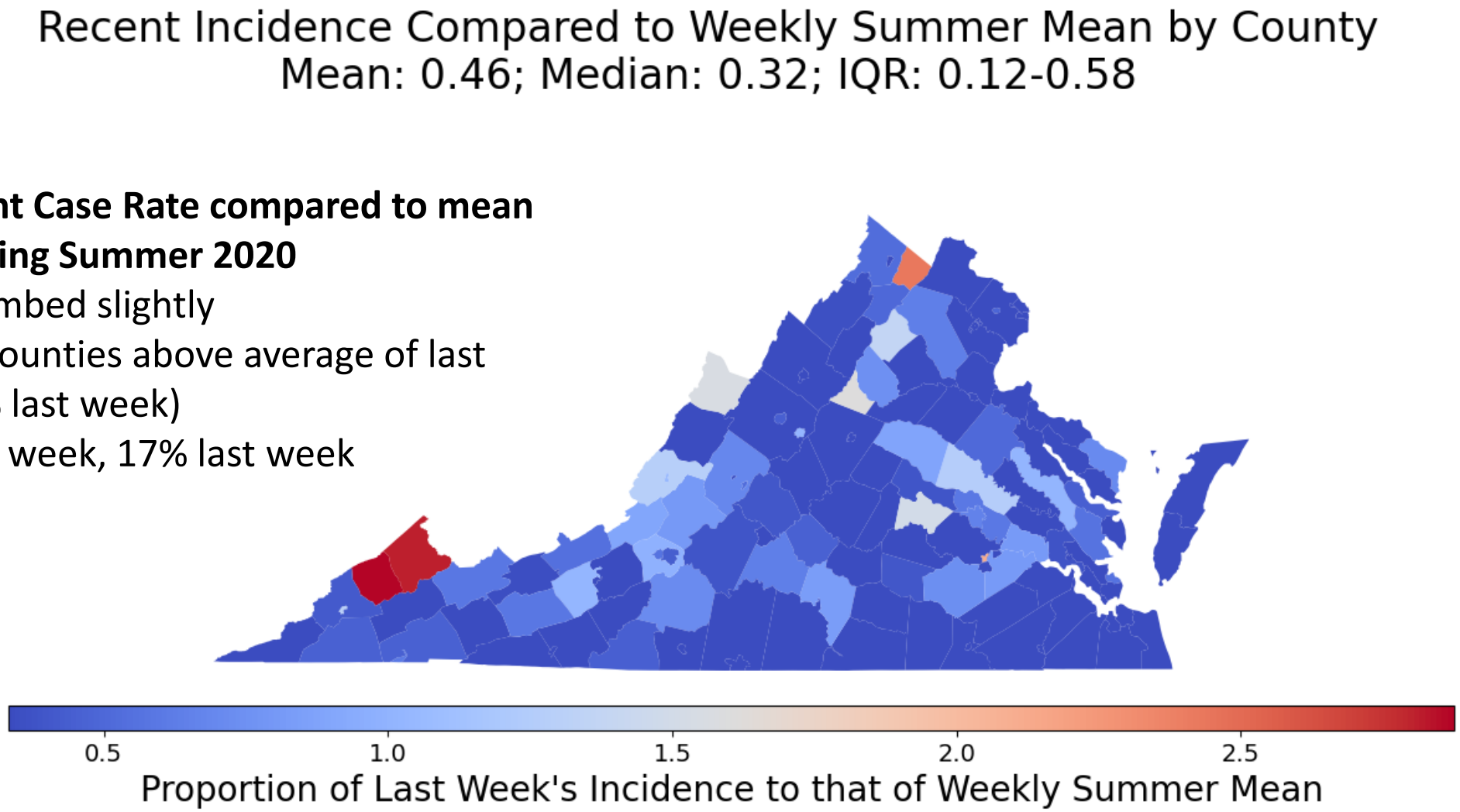
Case Rate Change in last 14 days



Death Rate Change in last 14 days



Recent Incidence Compared to Summer 2020



Ratio of Recent Case Rate compared to mean Case Rate during Summer 2020

- Ratio has climbed slightly
- VA: 11% of counties above average of last summer (9% last week)
- US: 19% this week, 17% last week

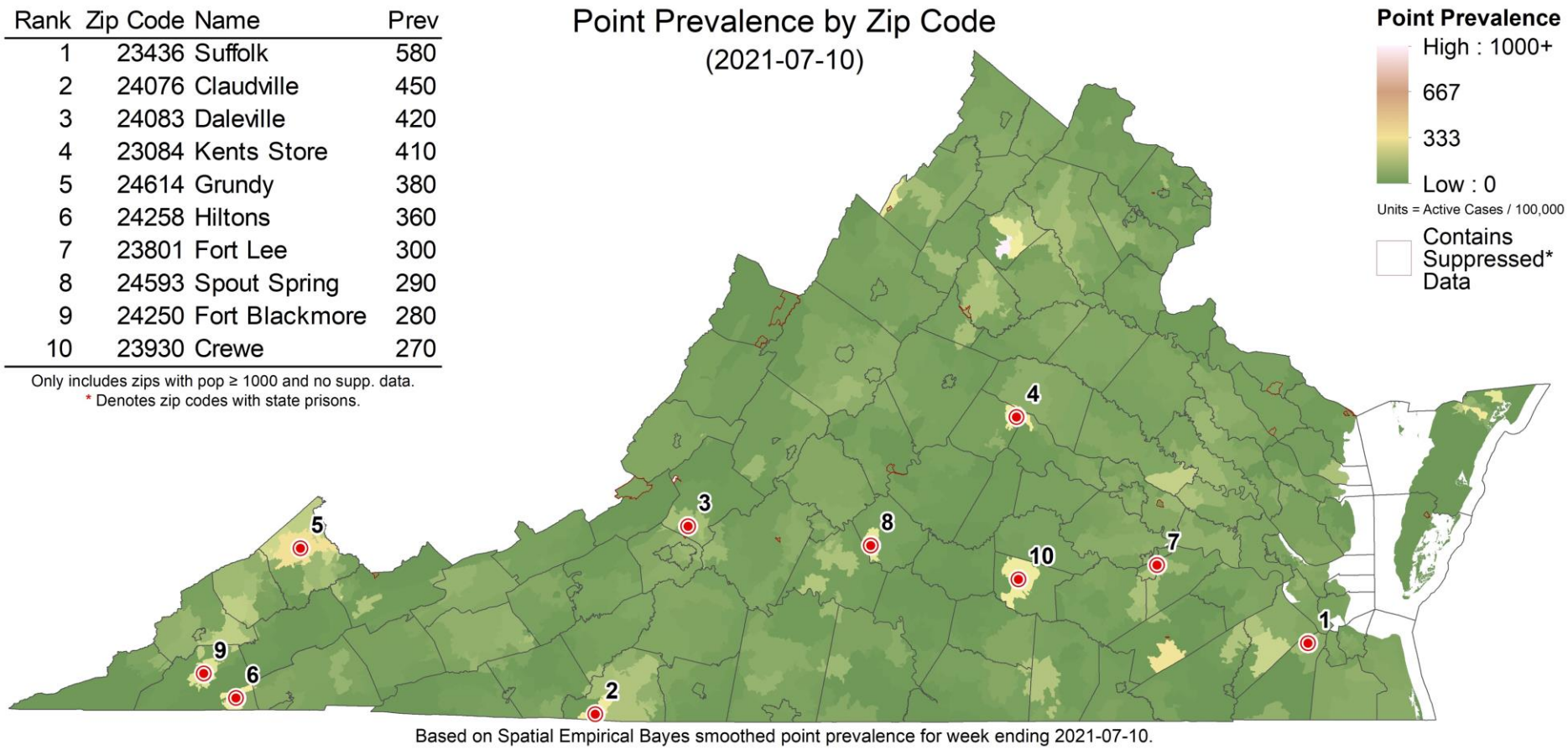
Zip code level weekly Case Rate (per 100K)

Case Rates in the last week by zip code

- Adjusted Color gradient to lower rates, thus red is a lower prevalence
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prev
1	23436	Suffolk	580
2	24076	Claudville	450
3	24083	Daleville	420
4	23084	Kents Store	410
5	24614	Grundy	380
6	24258	Hiltons	360
7	23801	Fort Lee	300
8	24593	Spout Spring	290
9	24250	Fort Blackmore	280
10	23930	Crewe	270

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2021-07-10.

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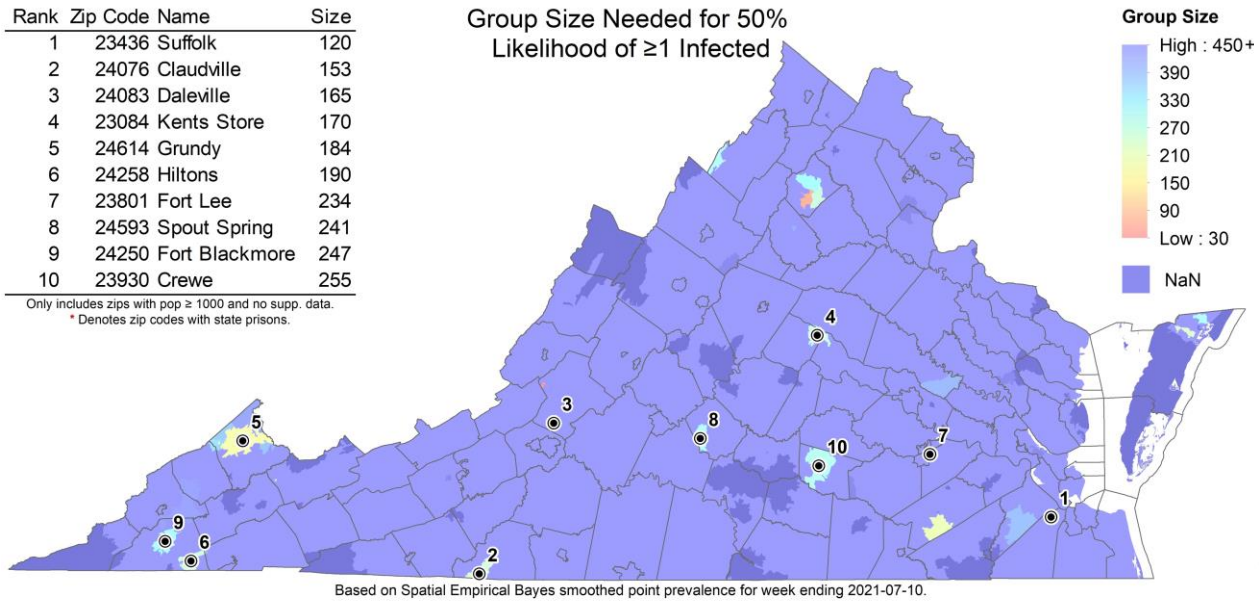
Risk of Exposure by Group Size and HCW prevalence

Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)

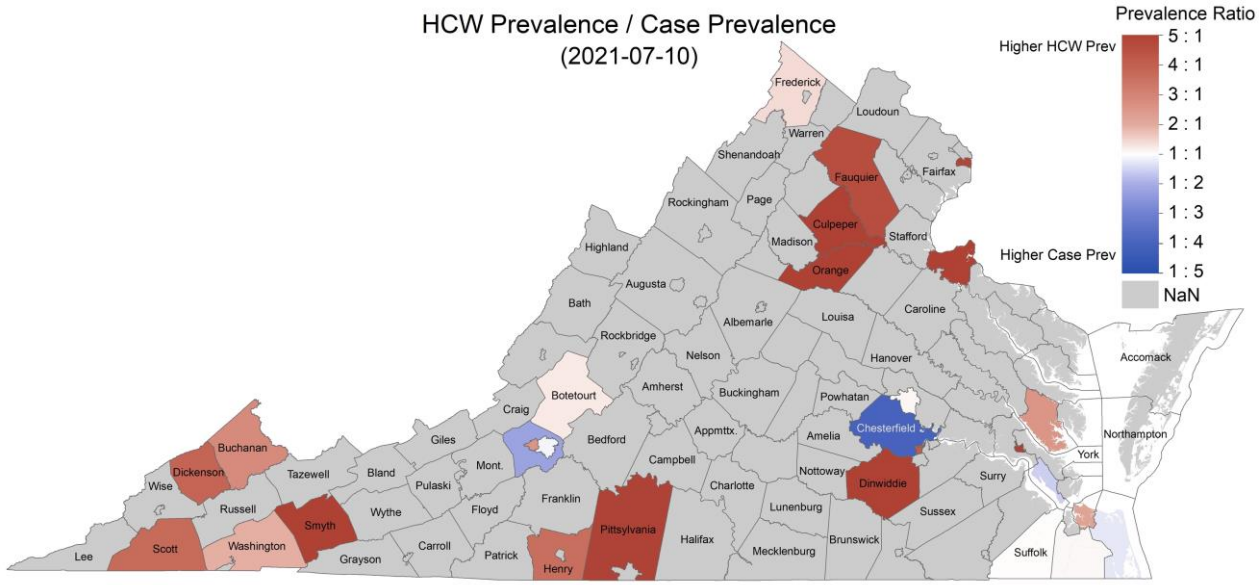
- **Group Size**: Assumes 2 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey), and shows minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 120 in Suffolk, there is a 50% chance someone will be infected)
- **HCW prevalence**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator

Rank	Zip Code	Name	Size
1	23436	Suffolk	120
2	24076	Claudville	153
3	24083	Daleville	165
4	23084	Kents Store	170
5	24614	Grundy	184
6	24258	Hiltons	190
7	23801	Fort Lee	234
8	24593	Spout Spring	241
9	24250	Fort Blackmore	247
10	23930	Crewe	255

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2021-07-10.



Current Hot-Spots

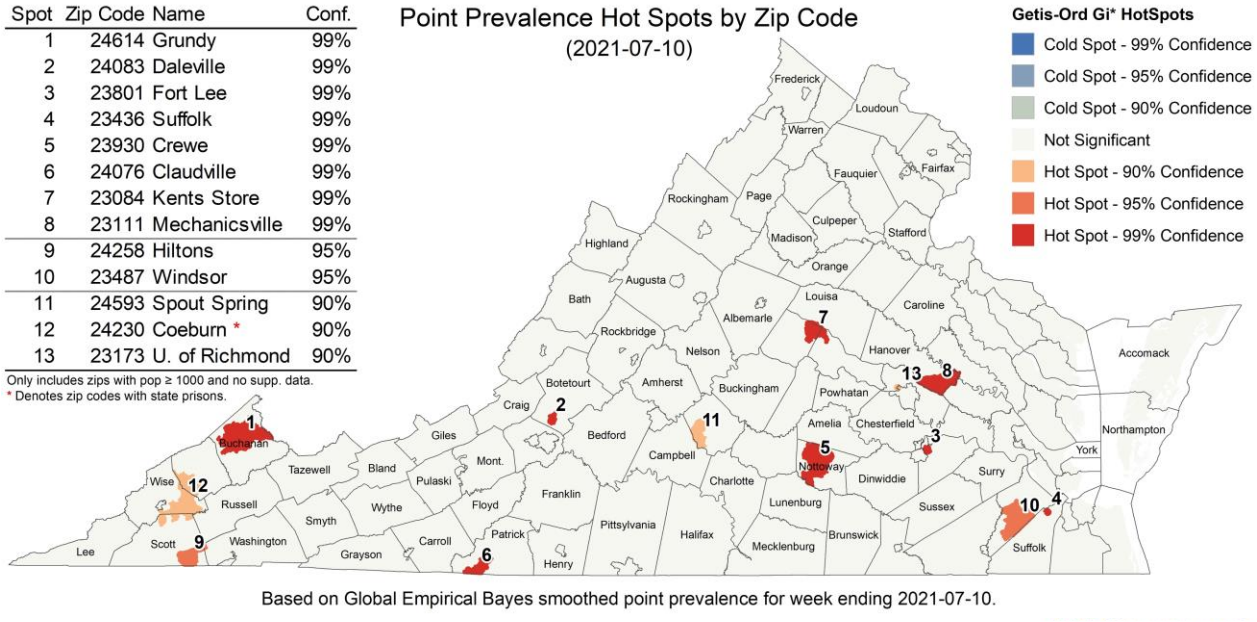
Case rates that are significantly different from neighboring areas or model projections

- **Spatial**: SaTScan based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal**: The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model's projections

Spatial Hotspots

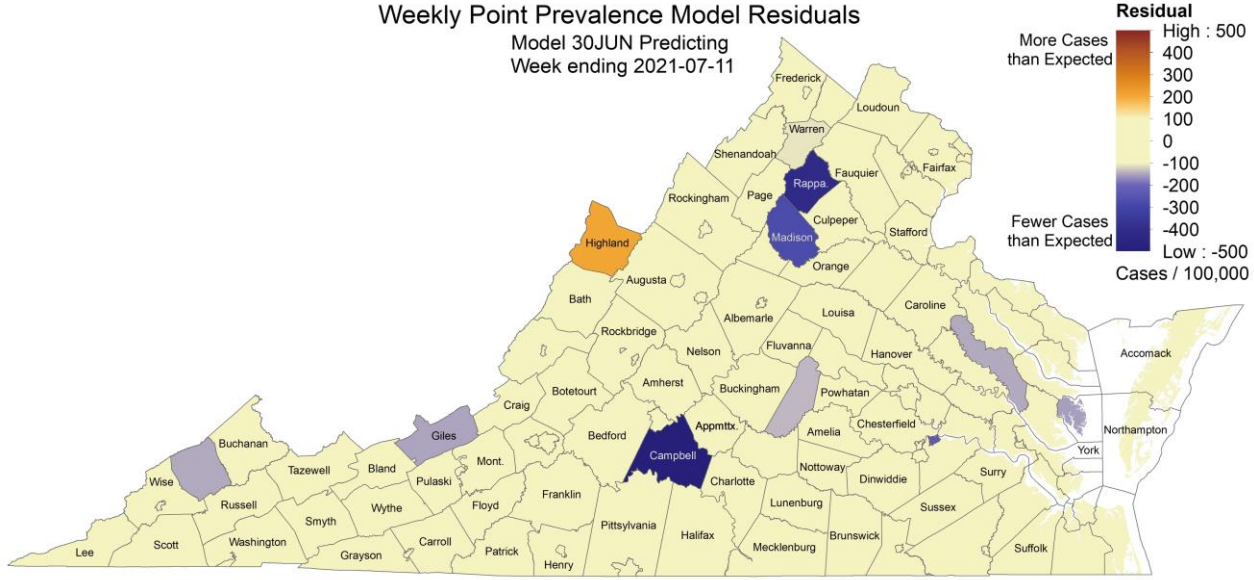
Spot	Zip Code	Name	Conf.
1	24614	Grundy	99%
2	24083	Daleville	99%
3	23801	Fort Lee	99%
4	23436	Suffolk	99%
5	23930	Crewe	99%
6	24076	Claudville	99%
7	23084	Kents Store	99%
8	23111	Mechanicsville	99%
9	24258	Hiltons	95%
10	23487	Windsor	95%
11	24593	Spout Spring	90%
12	24230	Coeburn *	90%
13	23173	U. of Richmond	90%

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Global Empirical Bayes smoothed point prevalence for week ending 2021-07-10.

Clustered Temporal Hotspots

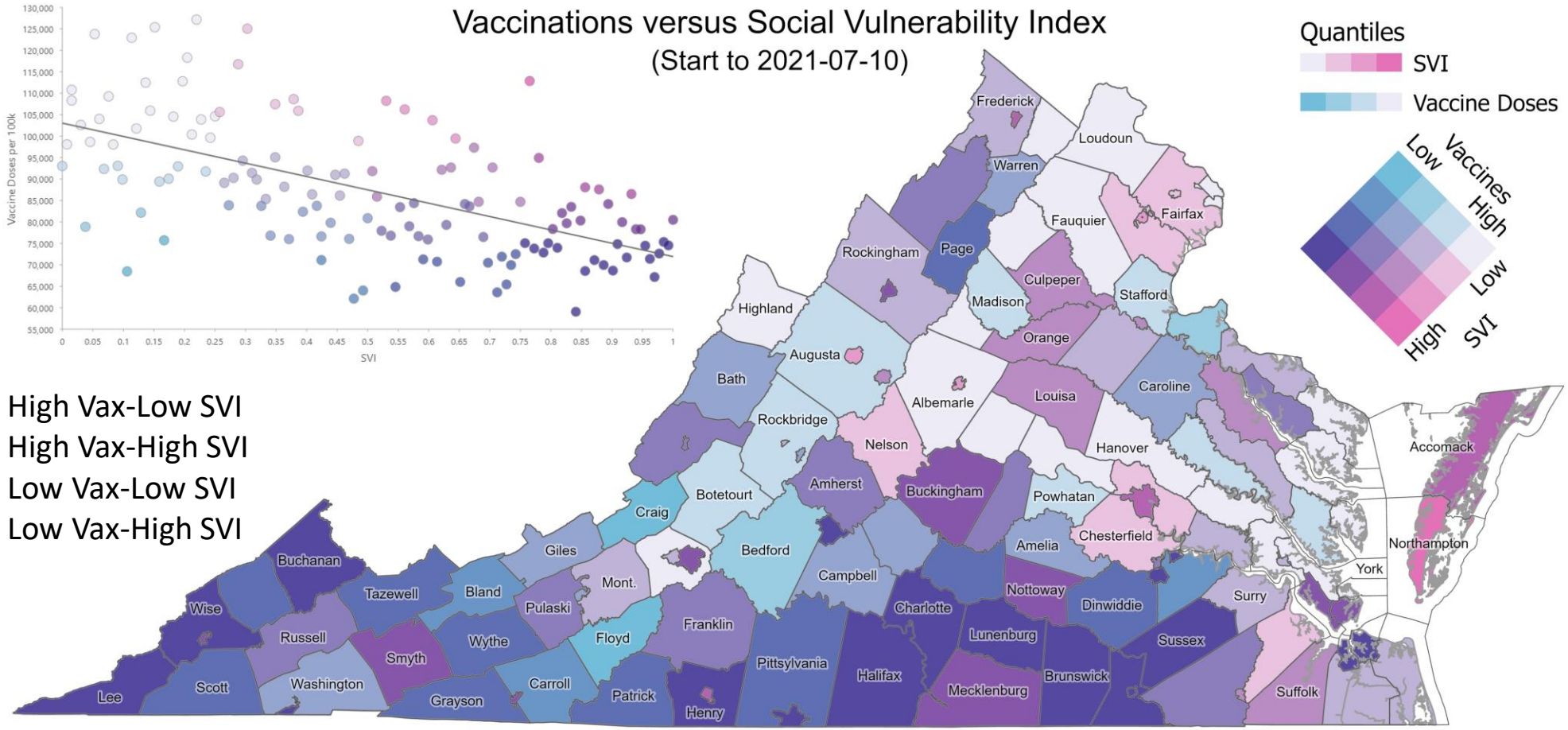


Moran's I = -0.003168, Z-Score = 0.164149, P-Value = 0.869614
No Residual Autocorrelation Detected

Social Vulnerability and Total Vaccination Rates

Comparison of social vulnerability and total vaccination rate since the start of vaccination

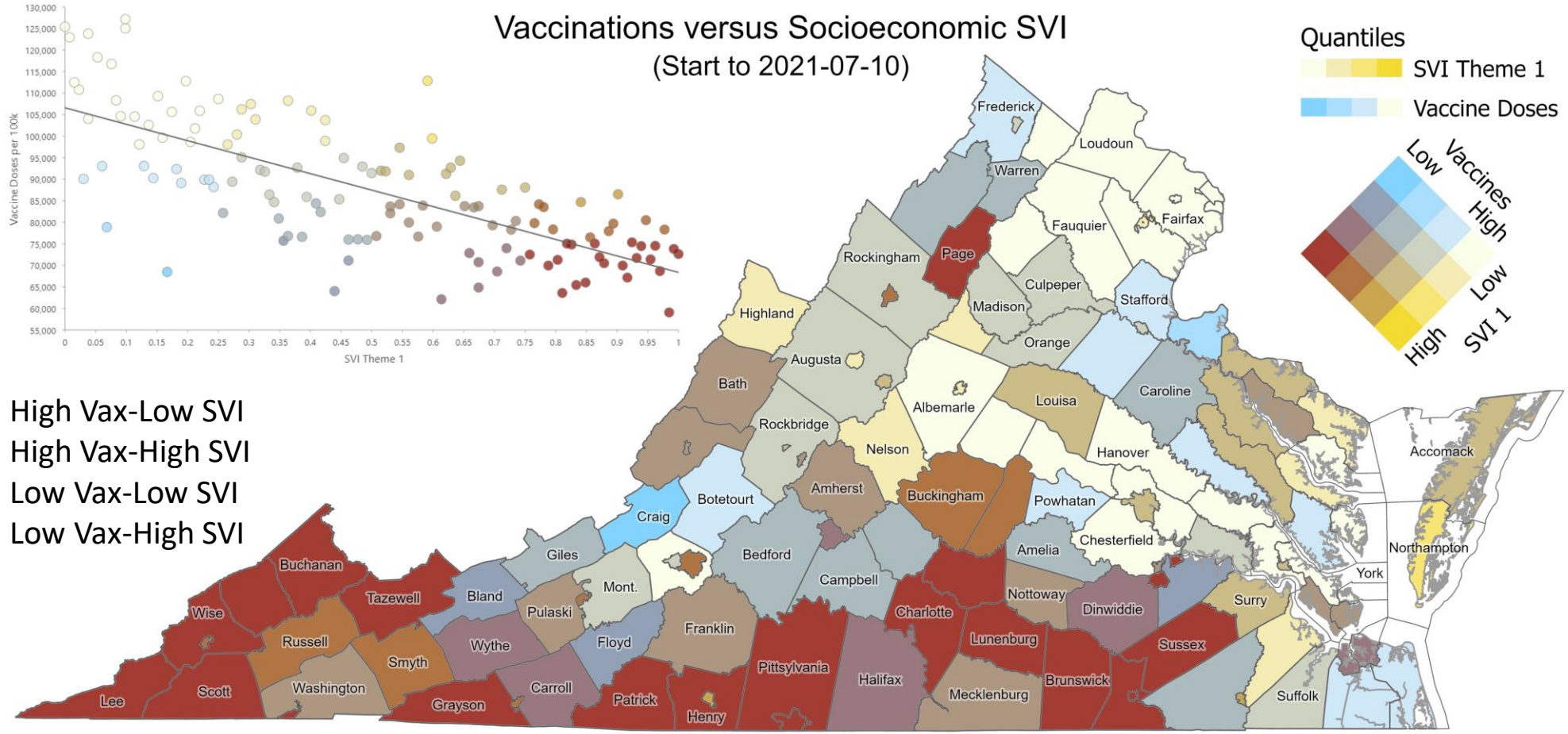
- **Social Vulnerability:** Each county's Social Vulnerability Index (CDC) compared with the level of vaccination



Social Vulnerability and Total Vaccination Rates

Comparison of social vulnerability and total vaccination rate since the start of vaccination

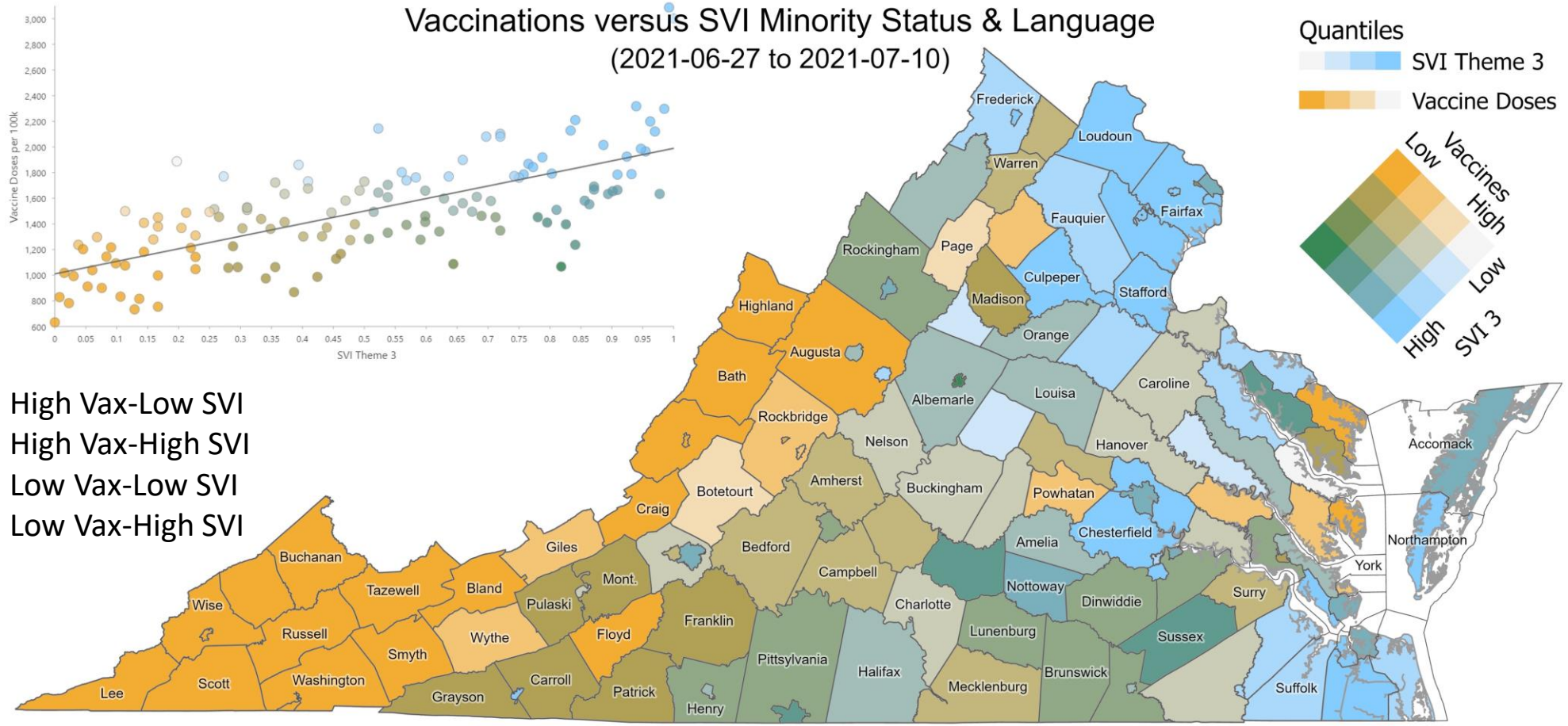
- **Socioeconomic Social Vulnerability:** Each county's Social Vulnerability Index – Socioeconomic component (CDC) compared with the level of vaccination, shows high SE vulnerability an low vaccination



Social Vulnerability and Total Vaccination Rates

Comparison of social vulnerability and total vaccination rate since the start of vaccination

- **Minority and Language Social Vulnerability:** Social Vulnerability Index – Minority and Language component (CDC) compared with the level of vaccination shows strong correlation of high ML SVI and high vaccination



Model Update – Adaptive Fitting

Adaptive Fitting Approach

Each county fit precisely, with recent trends used for future projection

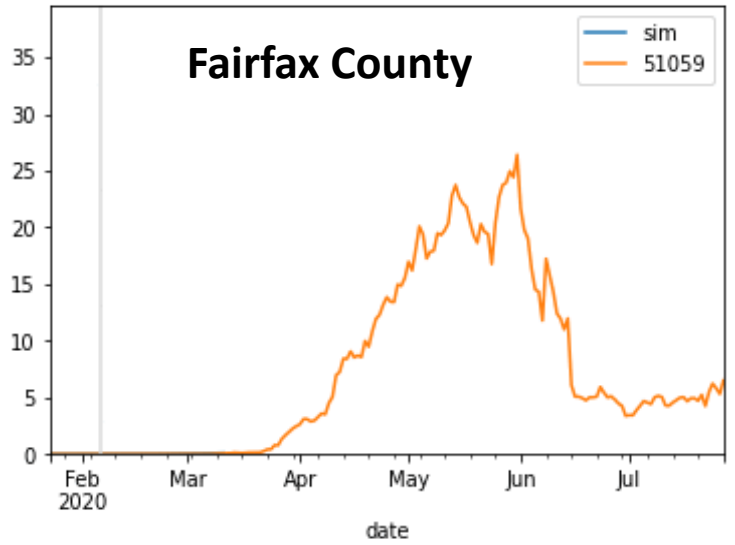
- Allows history to be precisely captured, and used to guide bounds on projections

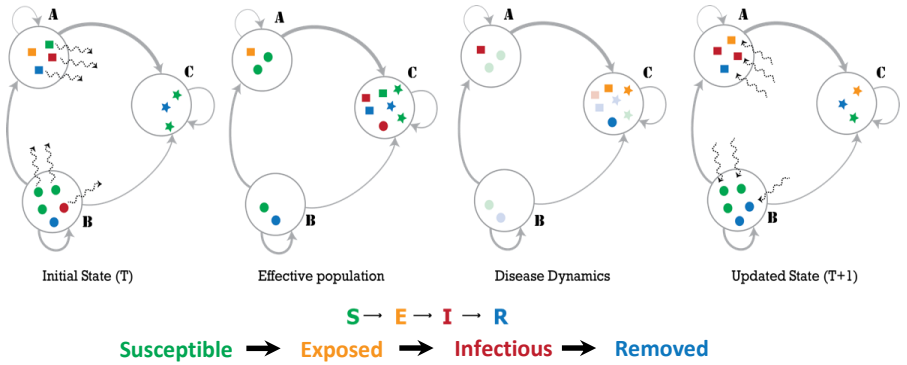
Model: An alternative use of the same meta-population model, PatchSim

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Eliminates connectivity between patches, to allow calibration to capture the increasingly unsynchronized epidemic

External Seeding: Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions
- Uses steady 1 case per 10M population per day external seeding





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Using Ensemble Model to Guide Projections

Ensemble methodology that combines the Adaptive with machine learning and statistical models such as:

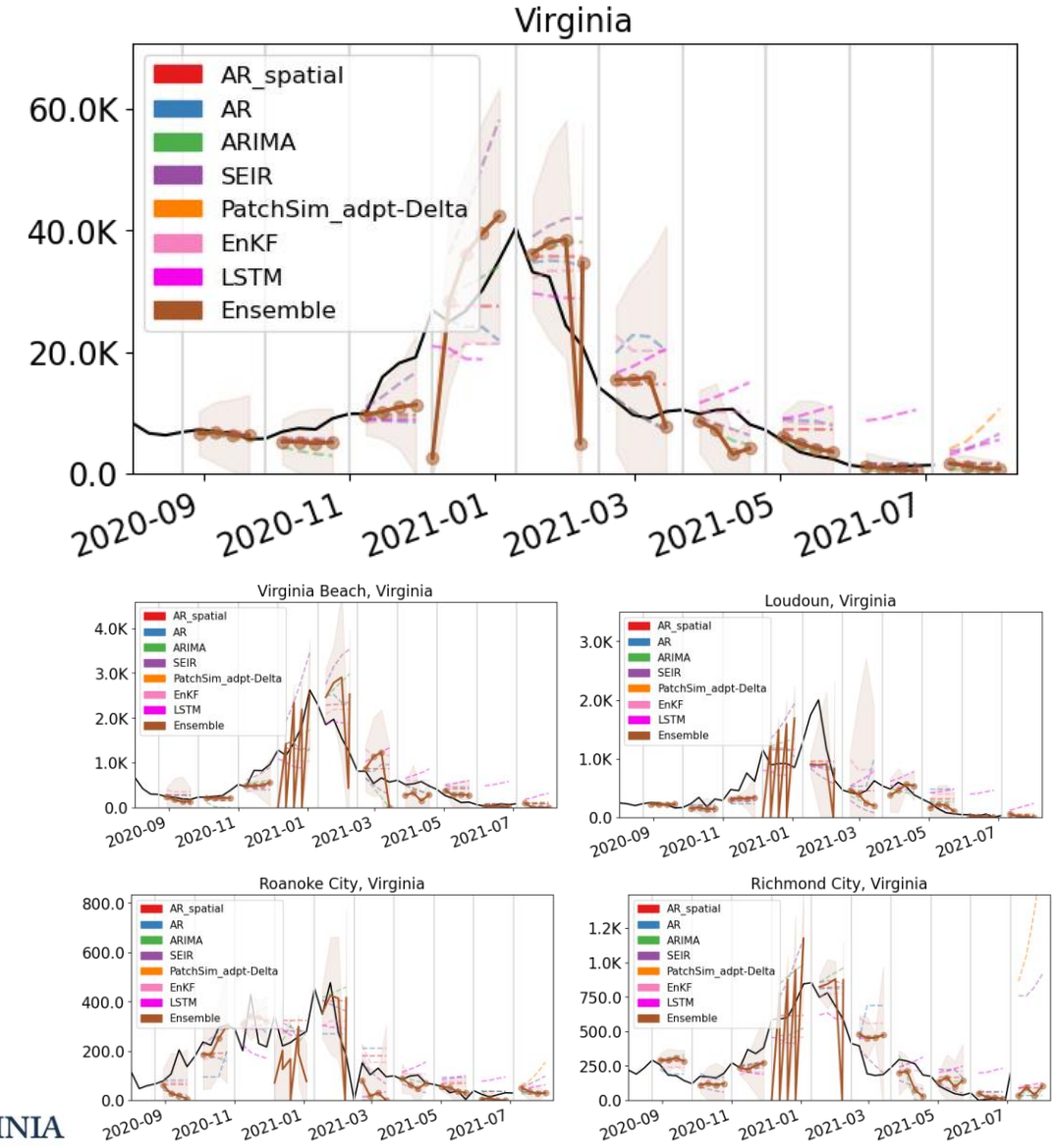
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<u>Weekly forecasts</u> done at county level.

Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

Ensemble forecast provides additional 'surveillance' for making scenario-based projections.

Also submitted to CDC Forecast Hub.



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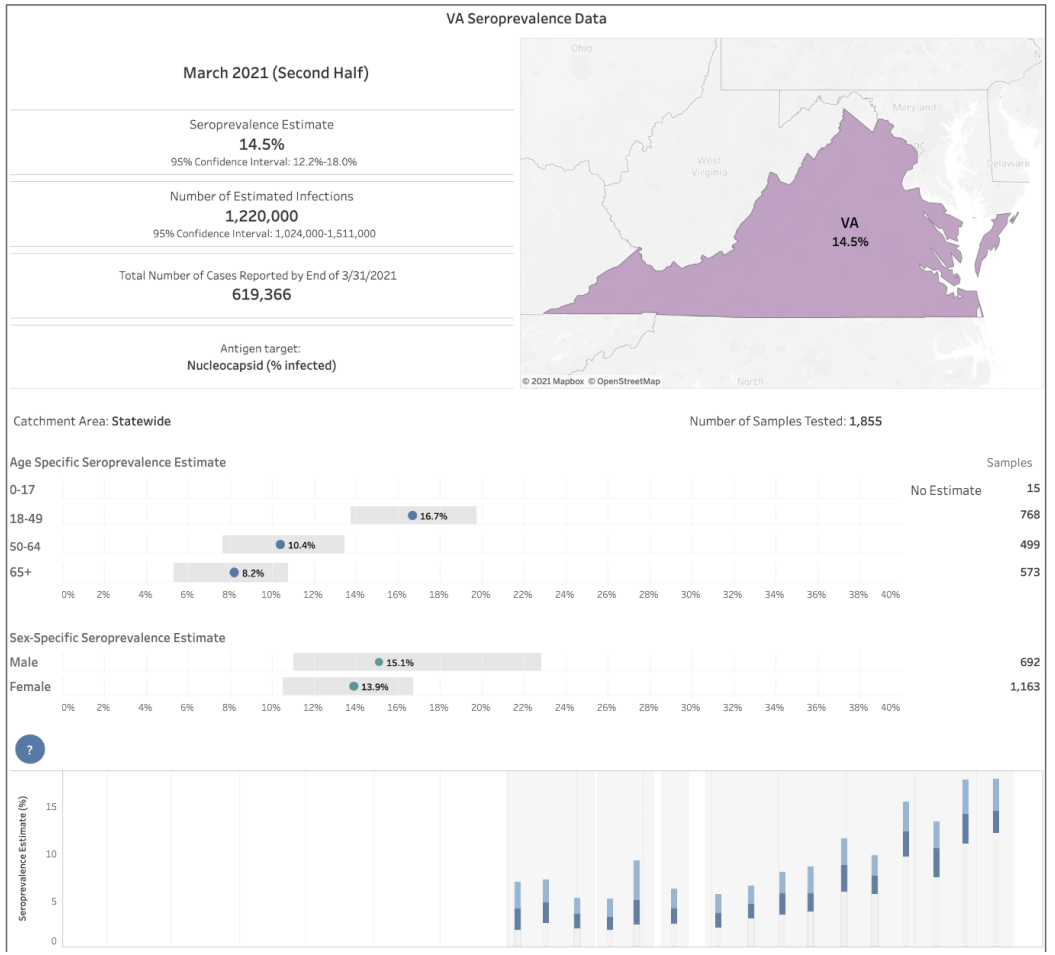
Seroprevalence updates to model design

Several seroprevalence studies provide better picture of how many actual infections have occurred

- CDC Nationwide Commercial Laboratory Seroprevalence Survey estimated 14.5% [12% – 18%] seroprevalence as of March 4th – 17th up from 10.5% a month earlier

These findings are equivalent to an ascertainment ratio of ~2x in the future, with bounds of (1.3x to 3x)

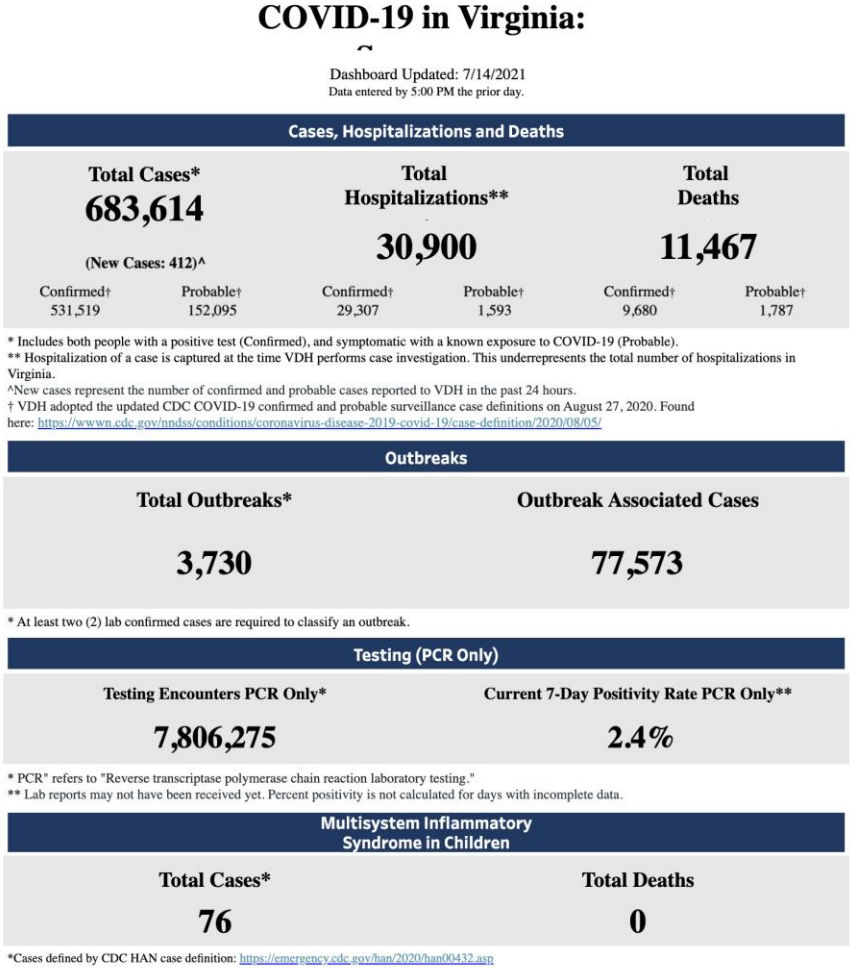
- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- This measure now fully tracks the estimated ascertainment over time
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being used)



https://covid.cdc.gov/covid-data-tracker/#national-lab

Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories



COVID-19 in Virginia:

Dashboard Updated: 7/14/2021
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*		Total Hospitalizations**		Total Deaths	
683,614		30,900		11,467	
(New Cases: 412)^					
Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
531,519	152,095	29,307	1,593	9,680	1,787

* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).
** Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.
^New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.
† VDH adopted the updated CDC COVID-19 confirmed and probable surveillance case definitions on August 27, 2020. Found here: https://wwwn.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/08/05/

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
3,730	77,573

* At least two (2) lab confirmed cases are required to classify an outbreak.

Testing (PCR Only)

Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
7,806,275	2.4%

* PCR" refers to "Reverse transcriptase polymerase chain reaction laboratory testing."
** Lab reports may not have been received yet. Percent positivity is not calculated for days with incomplete data.

Multisystem Inflammatory Syndrome in Children

Total Cases*	Total Deaths
76	0

*Cases defined by CDC HAN case definition: https://emergency.cdc.gov/han/2020/han00432.asp

Accessed 10:00am July 14, 2021
https://www.vdh.virginia.gov/coronavirus/

Scenarios – Transmission Conditions

- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- Plausible levels of transmission can be bounded by past experience
  - Assess transmission levels at the county level from May 1, 2020 – Sept 1, 2020 or current, whichever is highest
- Projection Scenario:
  - **Adaptive:** Control remains as is currently experienced into the future
- Additional study scenarios with Fall Resurgence:
  - **Fall:** Resurgence to worst of Fall 2020 starting in September and ramping up quickly
  - **Fatigued Control**:
    - Highest level of transmission (95th percentile) increased by additional 5%
    - Transition to this level over 4 weeks, remain at this level for the summer, then return to Adaptive

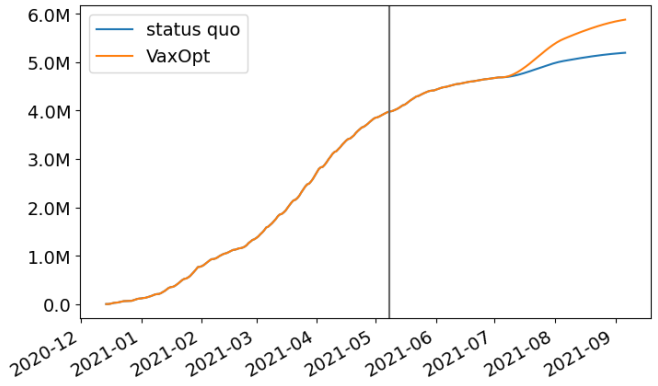
Scenarios – Vaccination Conditions

Vaccine Characteristics

- **Pfizer/Moderna**: 50% after first dose, 95% after second dose (3.5 week gap)
- **J & J** : 67% efficacy after first (and only) dose
- Delay to efficacy from doses is 14 days, immunity lasts at least 7m (NEJM study)

Vaccine Administration Scenarios

- **Status quo (no label):** COVIDcast corrected acceptance estimates (statewide mean is ~73%) reached by Labor Day.
- **Optimistic (VaxOpt):** Expand VA mean acceptance to ~85% (with all counties reaching a minimum of 65%, max of 95%).
- Acceptance at county level = regional acceptance +/- relative current vax
- Front-loaded rollout (two-thirds of the remaining in half the time)

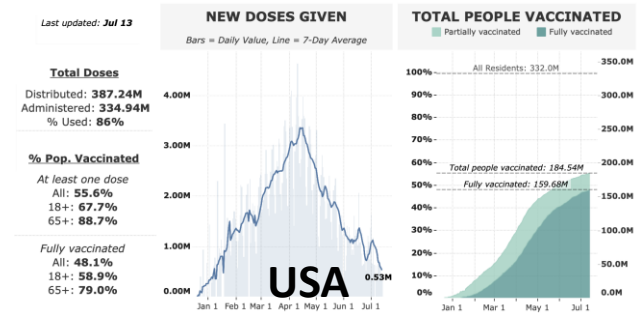


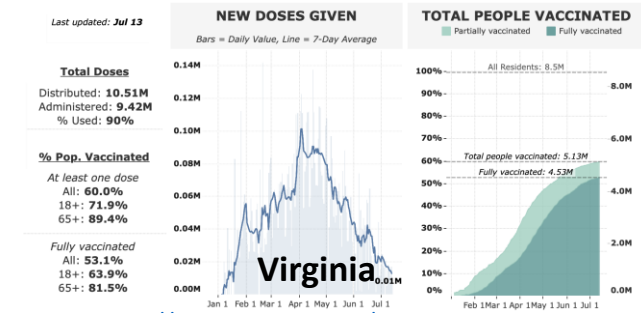
Monthly first doses

Date	status quo	VaxOpt
2020-12-31	113.3K	113.3K
2021-01-31	655.9K	655.9K
2021-02-28	569.7K	569.7K
2021-03-31	1.3M	1.3M
2021-04-30	1.2M	1.2M
2021-05-31	583.5K	583.5K
2021-06-30	241.3K	254.8K
2021-07-31	350.1K	784.5K
2021-08-31	175.7K	390.1K
2021-09-30	19.1K	42.2K

Cumulative

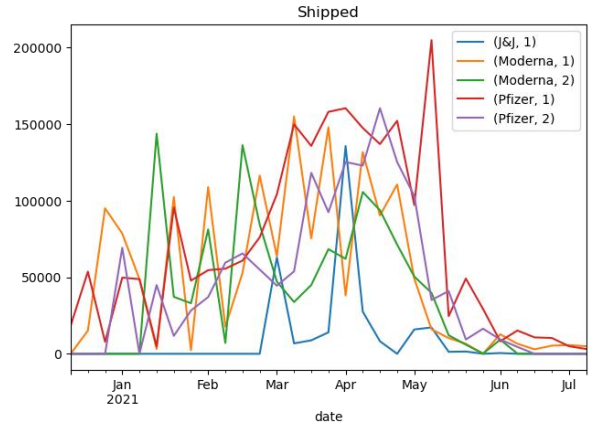
Date	status quo	VaxOpt
2020-12-31	113.3K	113.3K
2021-01-31	769.2K	769.2K
2021-02-28	1.3M	1.3M
2021-03-31	2.7M	2.7M
2021-04-30	3.8M	3.8M
2021-05-31	4.4M	4.4M
2021-06-30	4.6M	4.7M
2021-07-31	5.0M	5.4M
2021-08-31	5.2M	5.8M
2021-09-30	5.2M	5.9M





Source: https://ckelly17.github.io/vaccine_dashboard.html

Weekly VA doses administered by manufacturer



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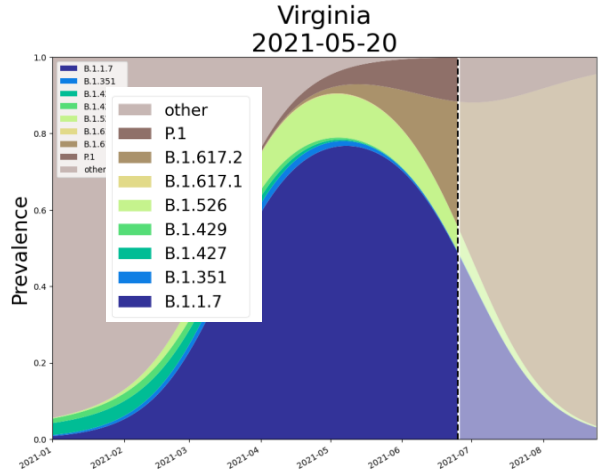
Scenarios – Delta δ Variant Condition

Variant Delta δ has exhibited ability to outcompete other variants and now is dominant in the US and most states

Transmissibility: Delta's relative transmissibility compared to Alpha is better understood (60% more transmissible) and its weighted growth fits a 60% growth advantage well

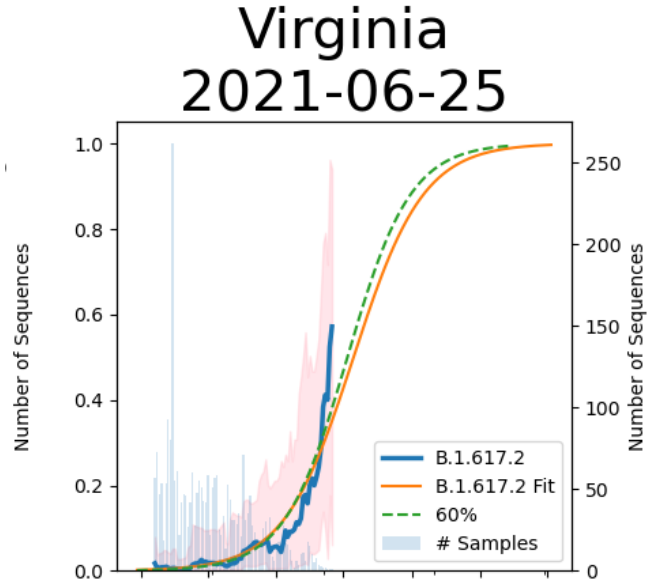
Immune Escape: Delta has been observed to evade immunity, both natural and vaccine-induced, however, uncertainty remains high thus this is **NOT** factored into the model

Severity: Delta, similar to alpha, appears to cause more severe illness with estimates ranging from 50% to 200%, at the moment assume 60%



outbreak.info GISAID

Outbreak Info



Delta Variant Scenario:

- Continues to grow on 60% more transmissible trajectory, reaches 50% prevalence on July 2nd and is also 60% more severe than alpha

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Projection Scenarios – Combined Conditions

Name	Txm Controls	Variant Boosting	Vax	Description
Adaptive	C	None	SQ	Likely trajectory based on conditions remaining similar to how they are now
Adaptive-VaxOpt	C	None	VO	Vaccination through Labor Day reaches an optimistically high level of expanded coverage (85%)
Adaptive-Delta	C	60%	SQ	Likely trajectory based on conditions remaining similar to now, but with increasing prevalence of Delta variant
Adaptive-Delta-VaxOpt	C	60%	VO	Vaccination through Labor Day reaches an optimistically high level of expanded coverage (85%), with increasing prevalence of Delta variant

Transmission Controls: C = Current levels persist into the future
F = Fatiguing controls drift to worst levels of last summer and persist

Variant Boosting: None = Variety of variants, no future txm boosting, but with severity impacts from current levels
60% = Prevalence of Delta ramps up according to logistic growth and is 60% more transmissible

Vaccinations: SQ = Status quo acceptance leads to low rates of vaccination through the summer
VO = Vaccination acceptance optimistically expands with increased rates through the summer

Study Scenarios – Additional Conditions

Name	Abbv	Description
Fall Surge	Fall	Shift to worst transmission from Fall 2020 starting on Labor day and continue for 4 weeks to replicate increased transmission from seasonal effects and changes in human activities
Fatiguing Control Measures	FatigueControl	Worst case trajectory if control conditions deteriorate to highest transmission rates of the past

Added to existing conditions:

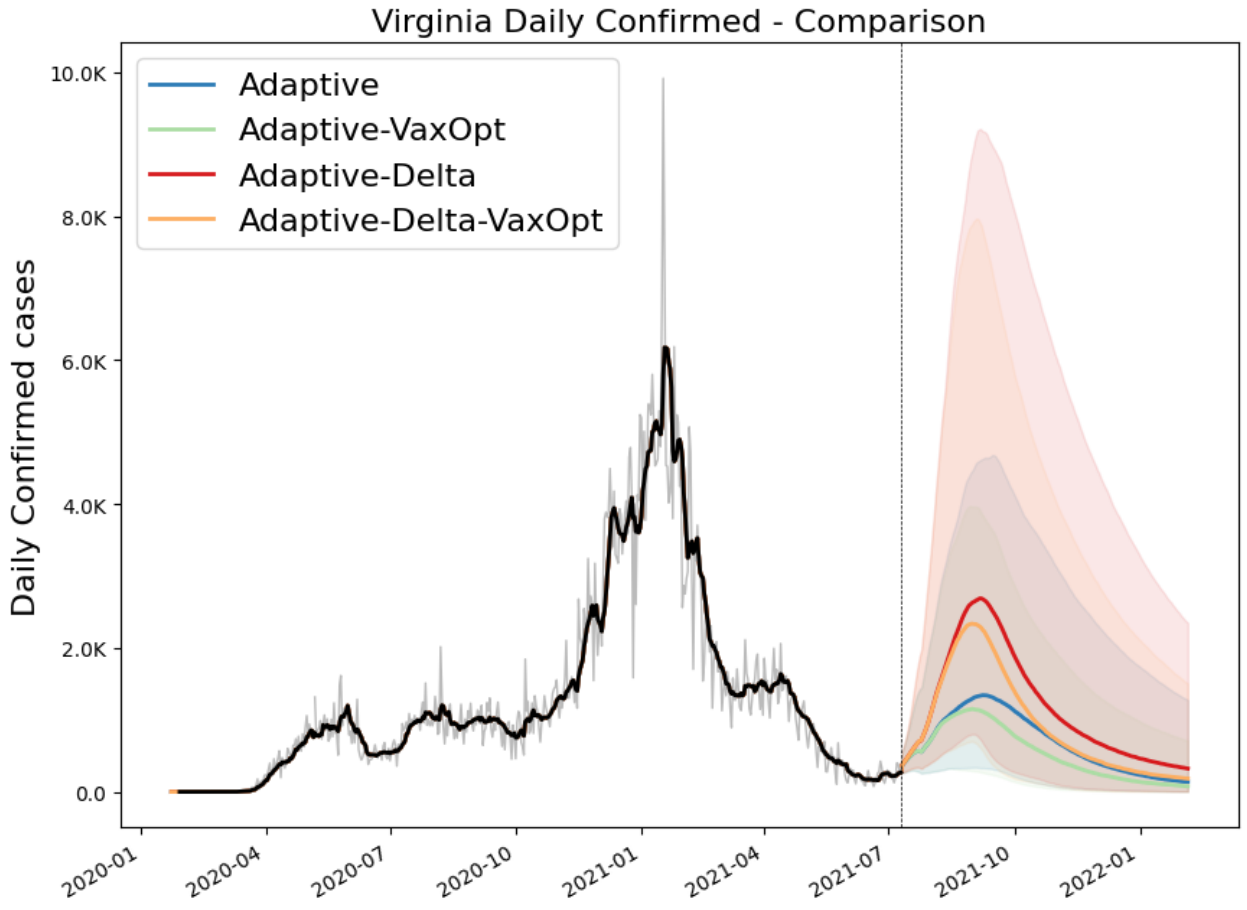
Variant Boosting: None = Variety of variants, no future txm boosting, but with severity impacts from current levels
60% = Prevalence of Delta ramps up according to logistic growth and is 60% more transmissible

Vaccinations: SQ = Status quo acceptance leads to low rates of vaccination through the summer
VO = Vaccination acceptance optimistically expands with increased rates through the summer

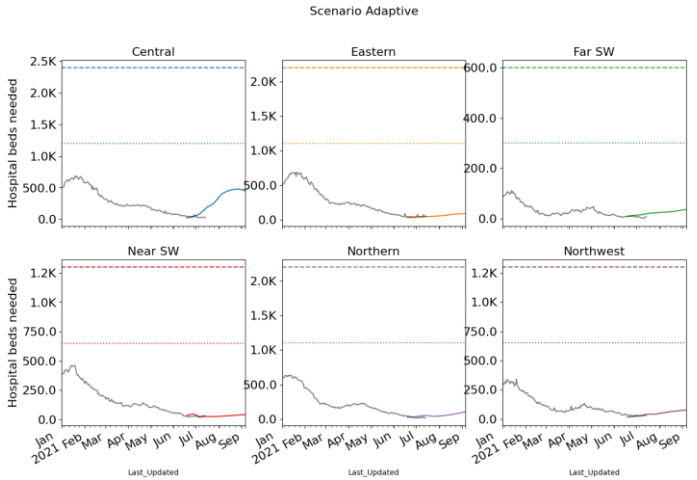
Model Results

Outcome Projections

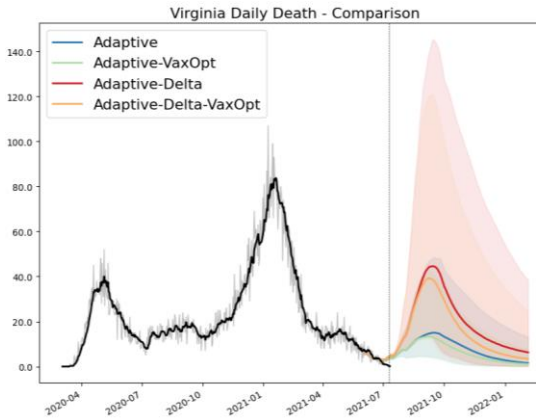
Confirmed cases



Estimated Hospital Occupancy

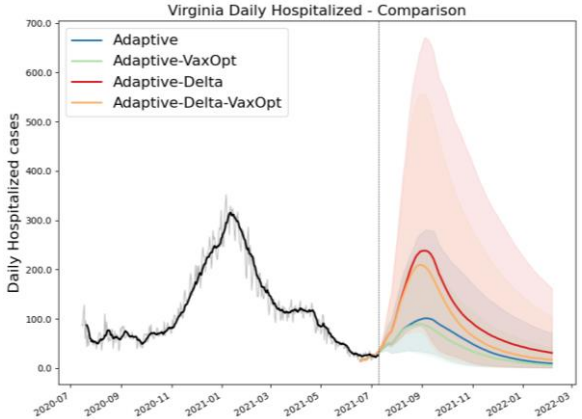


Daily Deaths



Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized



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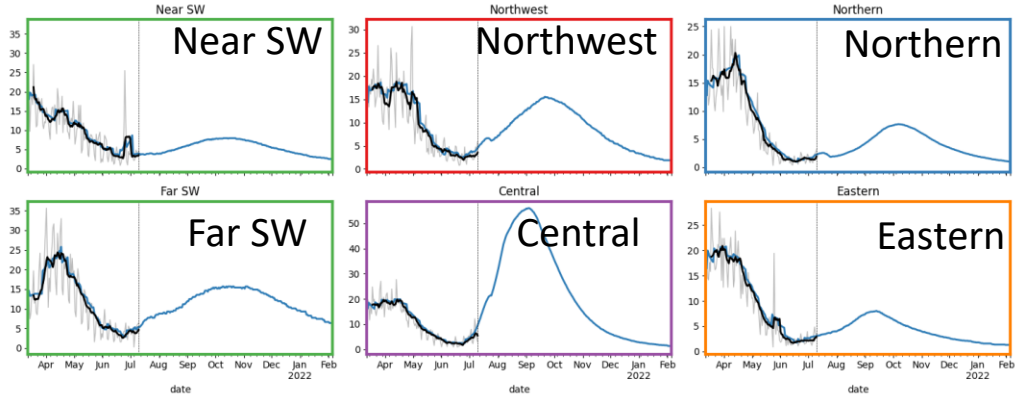
District Level Projections: Adaptive

Projections by Region

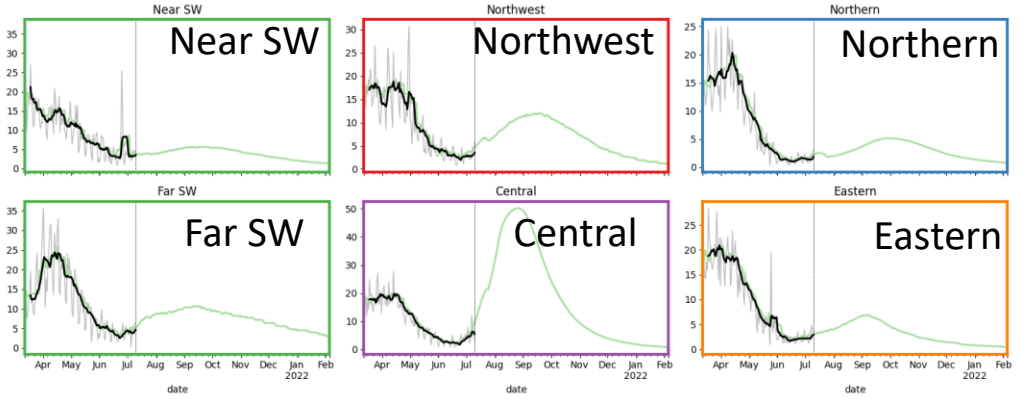


Projections by District

Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario

District Level Projections: Adaptive-VaxOpt

Projections by Region



Projections by District

Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario

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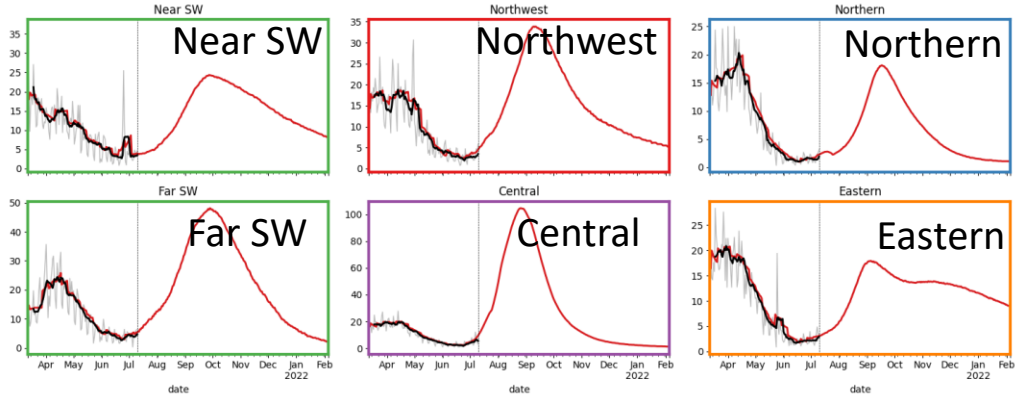
District Level Projections: Adaptive-Delta

Projections by Region

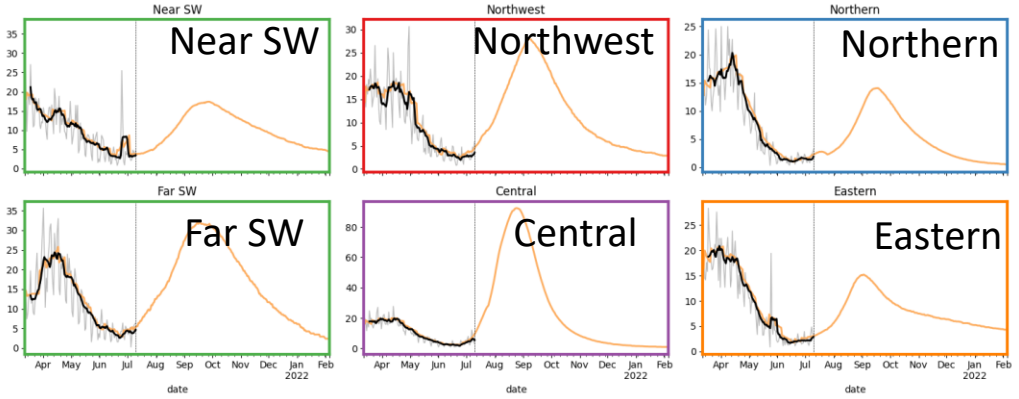


Projections by District

Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario

District Level Projections: Adaptive-Delta-VaxOpt

Projections by Region



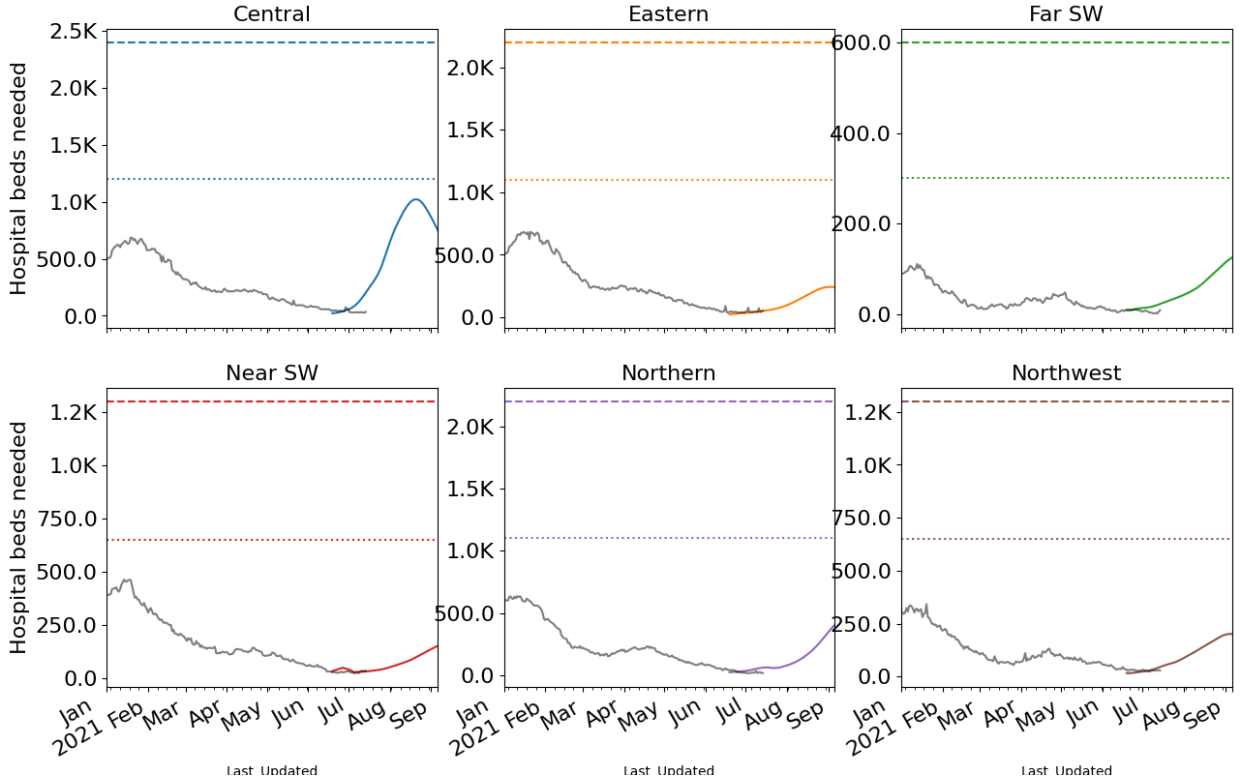
Projections by District

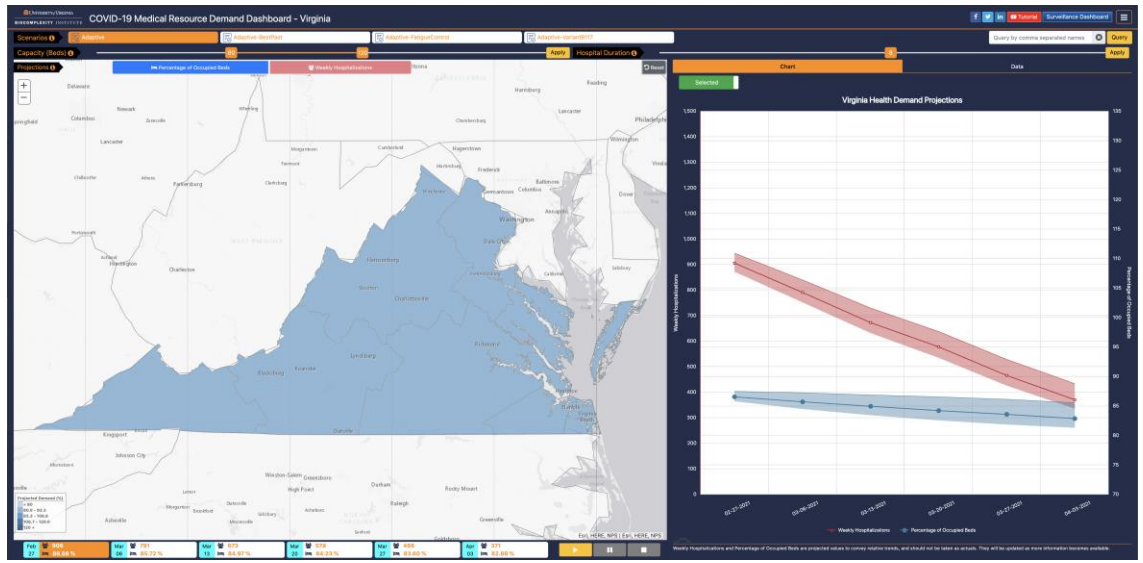
Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario

Hospital Demand and Bed Capacity by Region

Capacities* by Region – Adaptive-Delta

COVID-19 capacity ranges from 80% (dots) to 120% (dash) of total beds





https://nssac.bii.virginia.edu/covid-19/vmrddash/

Adaptive-FatigueControl-Delta scenario shows it remains possible to generate more hospitalizations:

- Far Southwest and Near Southwest have highest potential

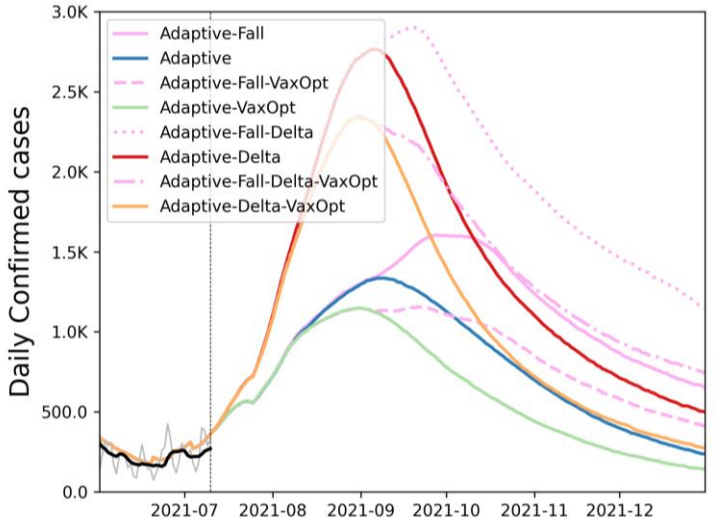
* Assumes average length of stay of 8 days

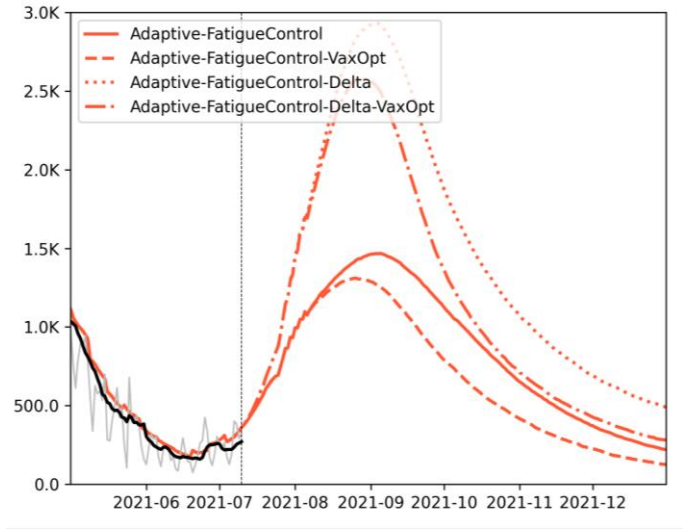
All Scenarios – Fall Surge and Optimistic Vaccination

Impact of expanded vaccine acceptance against a Fall Surge

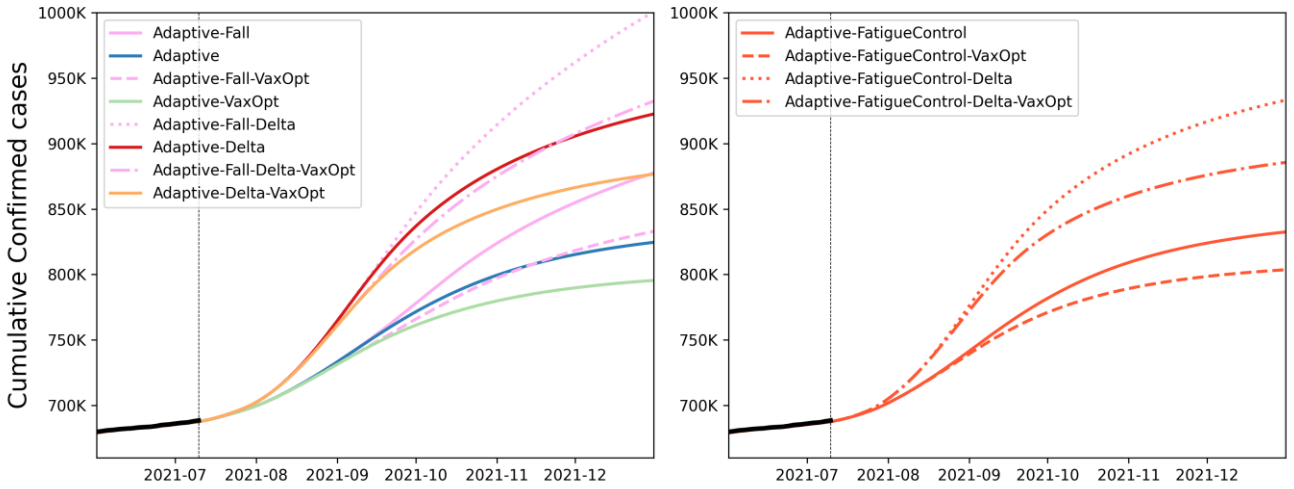
- Fall Surge on top of more prevalent Delta can create a sizeable spike in cases
- Expanded vaccination coverage to optimistic levels curtails the impact of a Fall Surge as well as Delta (50K-80K cases)
- Possibility of significant surge in fall given continued low vaccination coverage with presence of delta and seasonal effects

Daily Infections





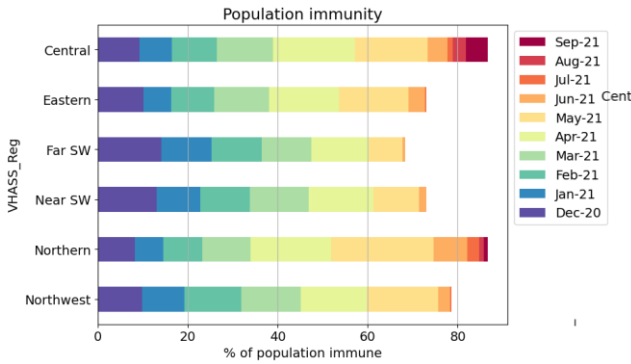
Cumulative Infections

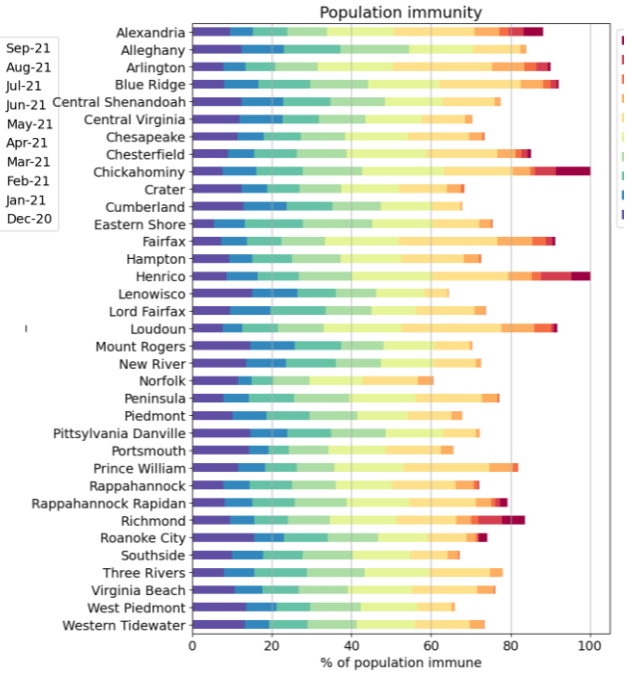


Virginia's Progress on Population Immunity

Natural Immunity and Vaccines combine to produce a population level of immunity

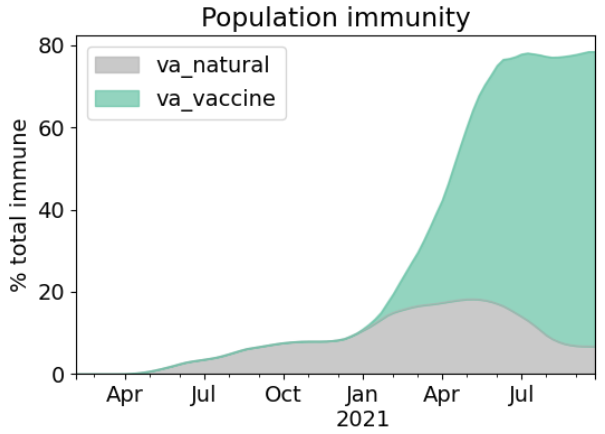
- Duration of immunity from infection with SARS-CoV2 still not well understood
  - We assume a conservative 6 month period of protection for these calculations
  - Natural immunity is well calibrated to recent seroprevalence surveys
- Vaccine induced immunity is likely to last longer, we assume indefinite protection
  - This also assumes that all administered vaccines remain protective against current and future novel variants
- Population immunity depends on a very high proportion of the population getting vaccinated
  - Using regional vaccine acceptance





Region	% immune (est.)*
Central	78%
Eastern	73%
Far SW	65%
Near SW	72%
Northern	84%
Northwest	78%
Virginia	78%

* As of July 11, 2021



Additional Analyses

Overview of relevant on-going studies

Other projects coordinated with CDC and VDH:

- **Scenario Modeling Hub:** Consortium of academic teams coordinated via MIDAS / CDC to that provides regular national projections based on timely scenarios
- **Genomic Surveillance:** Analyses of genomic sequencing data, VA surveillance data, and collaboration with VA DCLS to identify sample sizes needed to detect and track outbreaks driven by introduction of new variants etc.
- **Mobility Data driven Mobile Vaccine Clinic Site Selection:** Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify

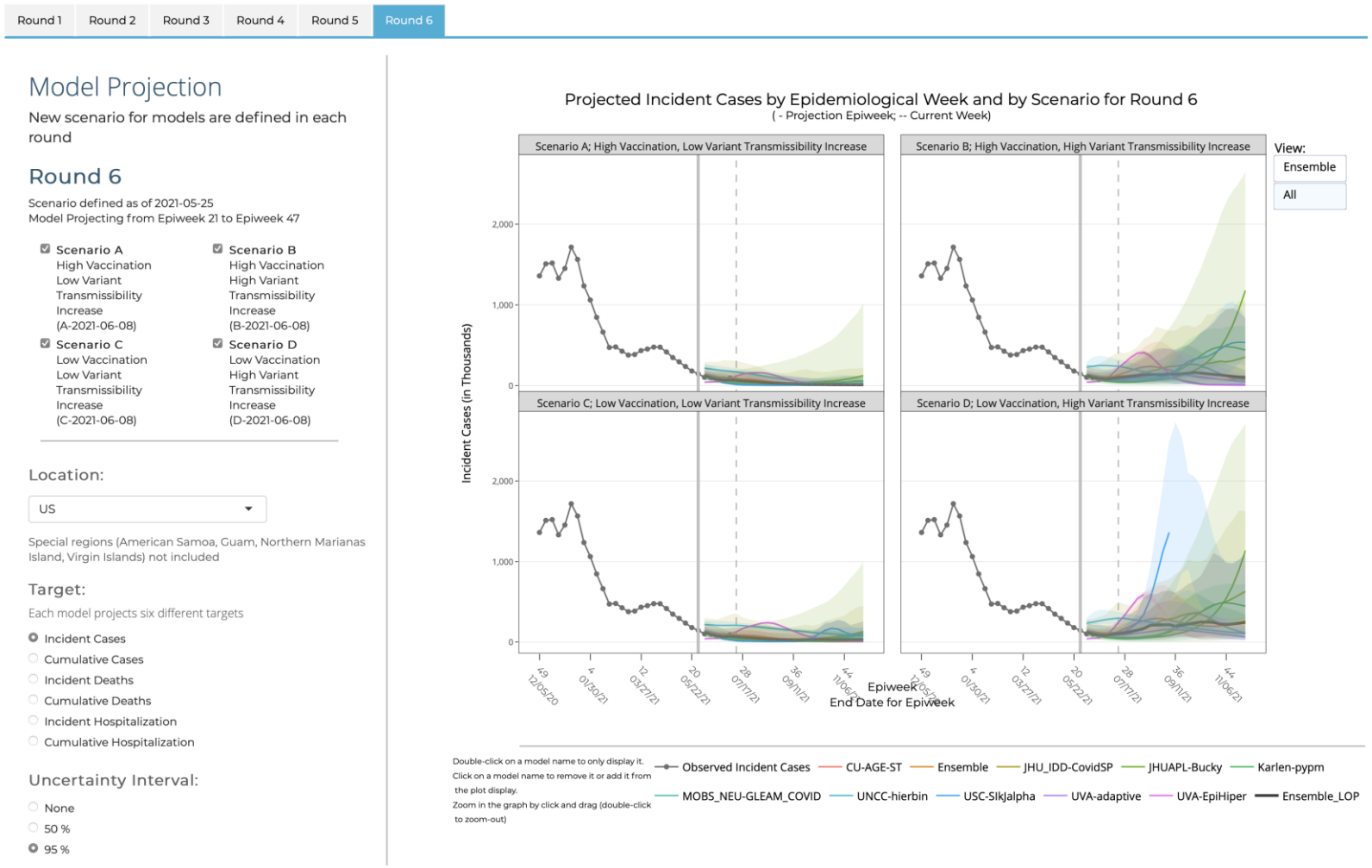
COVID-19 Scenario Modeling Hub

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios that vary vaccine rates (high – low) and levels of control (moderate and low)

- Round 7 concluded this week
- Round 6 available next week

Round 4 Results were published May 5th, 2021 in MMWR

https://covid19scenariomodelinghub.org/viz.html



COVID-19 Scenario Modeling Hub – Round 6

Round 7 scenarios explore the effects of a variant similar to the Delta (B.1.617.2) against different backgrounds of vaccination. Includes some vax escape

Vaccinations by Nov 30

- LowVacc – 70% overall coverage
- HighVacc – 80% overall coverage

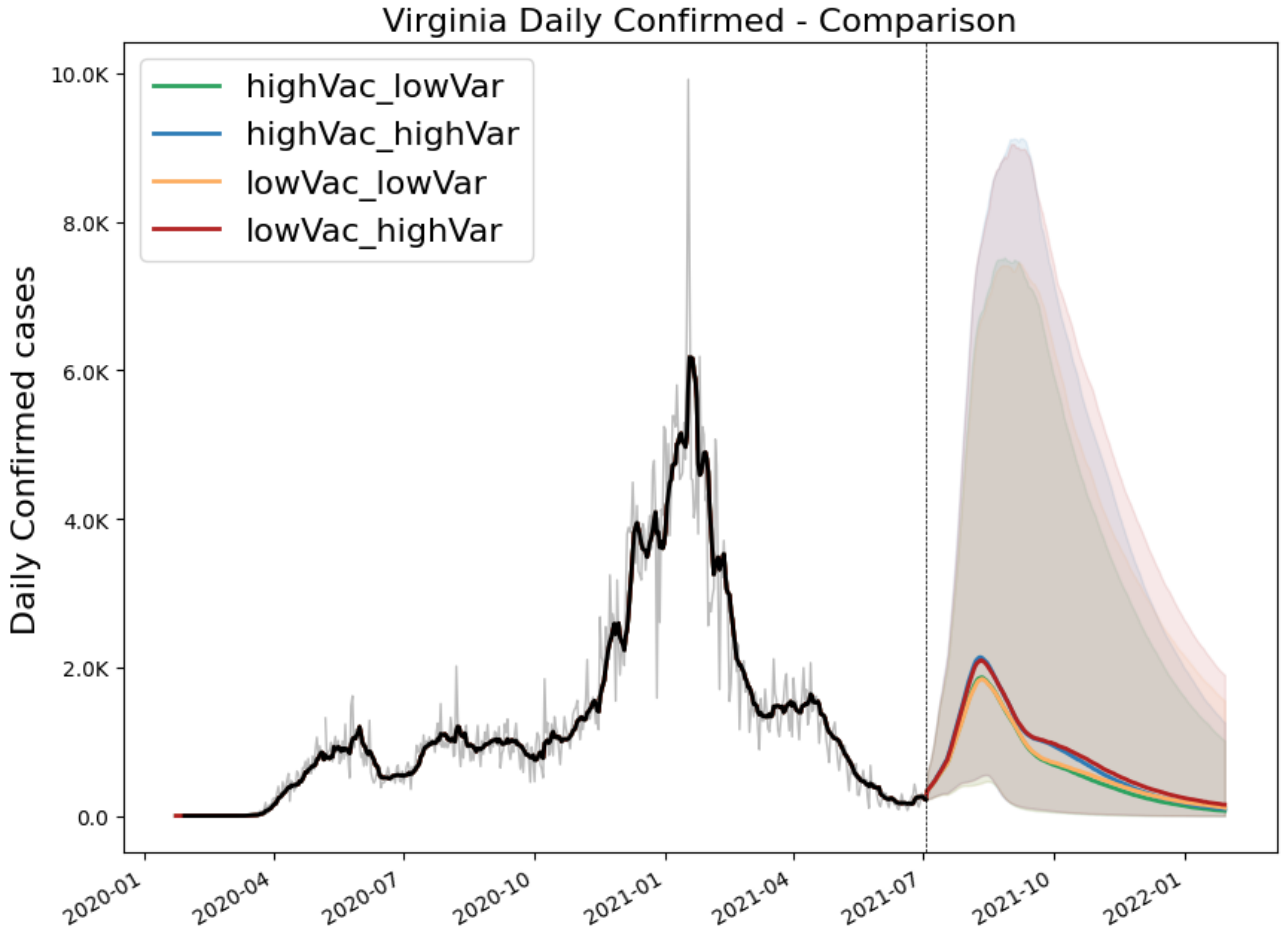
Emerging Variant Impact (5% prevalence on May 29th)

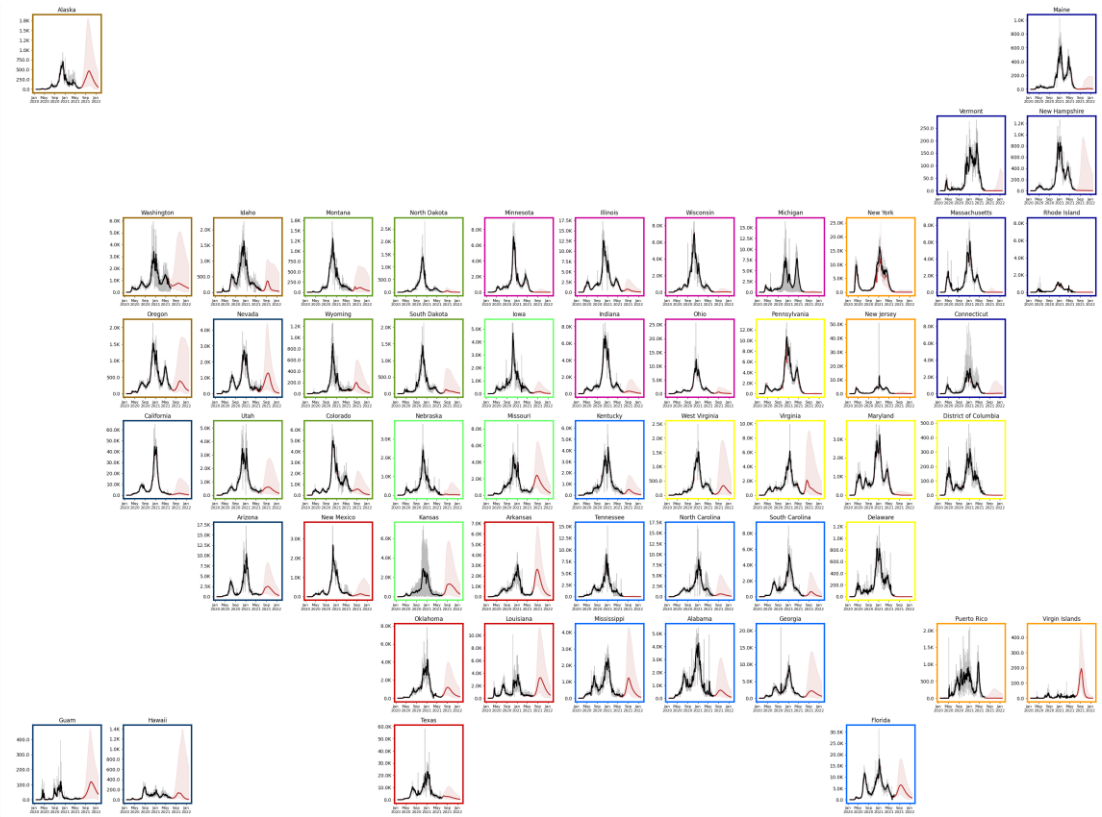
- LowVar – 40% more transmissible
- HighVar – 60% more transmissible

https://covid19scenariomodelinghub.org/viz.html

	LowVar	**HighVar**
See more detailed notes for each scenario below	**Low Impact Variant** *(low transmissibility increase, no immune escape)*	**High Impact Variant** *(high transmissibility increase, no immune escape)*
High Vaccination *(Low hesitancy)* **HighVacc**	***Scenario A*** Vaccination: - Coverage saturates at **80% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **50%/90%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: - **40% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.	***Scenario B*** Vaccination: - Coverage saturates at **80% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **35%/85%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: **60% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.
Low Vaccination *(High hesitancy)* **LowVacc**	***Scenario C*** Vaccination: - Coverage saturates at **70% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **50%/90%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: - **40% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.	***Scenario D*** Vaccination: - Coverage saturates at **70% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **35%/85%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: **60% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.

Modeling Hub – Round 7 Prelim Results

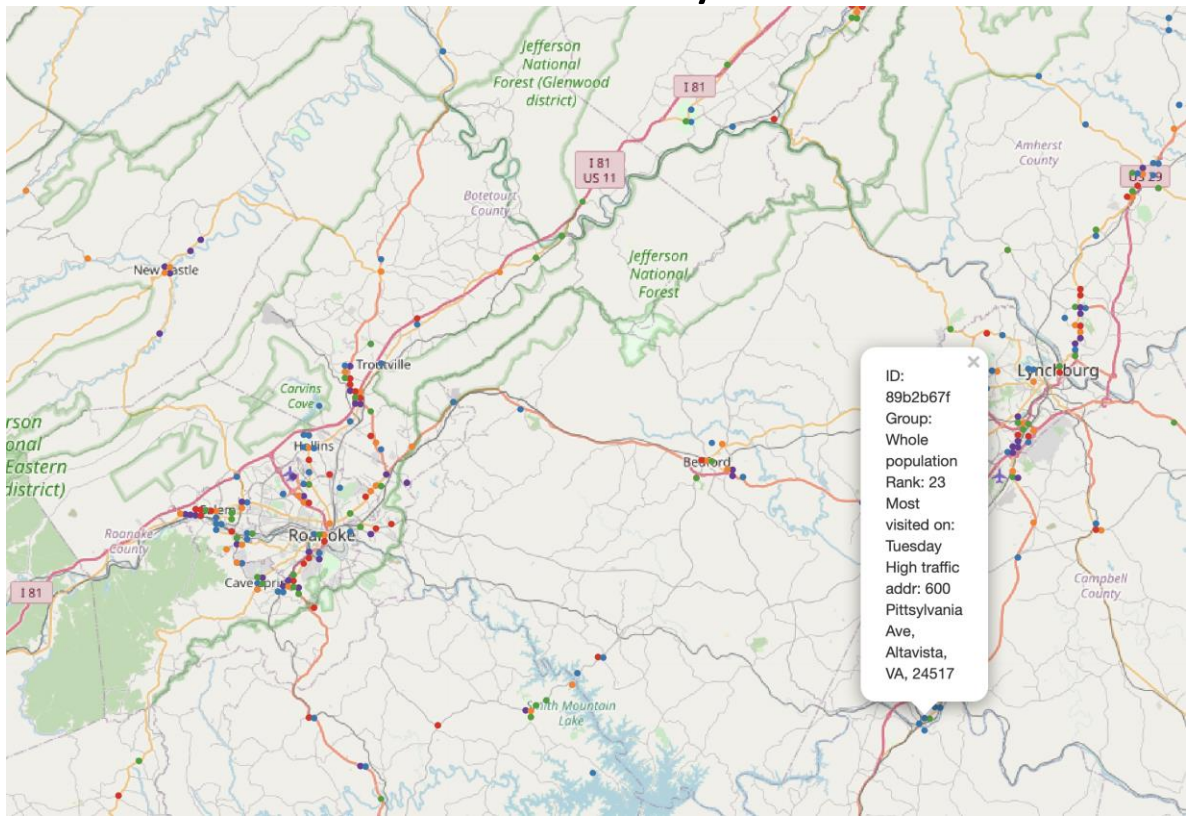




https://covid19scenariomodelinghub.org/viz.html

Data Recommended Mobile Vax Clinic Sites

Detailed and Timely Locations



Data Delivered and Disseminated to Locals

Provides a list of areas most visited by a given demographic group based on SafeGraph mobility data that links visits to specific sites and the home Census Block Group of the anonymized visitors

Demographic Groups: Black, Lantinx, Young Adults (20-40), Unvaccinated, and Whole Population

Data Included: Rank, Weight, most visited Day of Week, Highly Visited Address, and Lat-Long of area

Goal: Provide frequently visited locations based on populations and vaccination levels one desires to reach

Example: List of location in the Southside frequented by 20-40 year olds

Key Takeaways

Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

- **Case rates in Virginia have started to rise slightly**
- VA mean weekly incidence up to 3.1/100K from 2.1/100K, US up to 7.2/100K (from 4.2/100K)
- Fewer zip codes in Virginia (57%, 511 of 896 zips) had zero cases this past week (down from 63%)
- Vaccination acceptance remains among unvaccinated larger in some regions than others
- Projections show uptick in activity, with larger growth possible fueled by Delta's increasing prevalence
- Recent updates:
  - Delta variant dominates and has impacts on severity of disease
  - Study scenarios: Fall resurgence and Fatigued control spike in summer
  - Limited waning of natural immunity included in fit and projections, also with seroprevalence update
- The situation continues to change. Models continue to be updated regularly.

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NSSAC. PatchSim: Code for simulating the metapopulation SEIR model. https://github.com/NSSAC/PatchSim

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Biocomplexity Institute. COVID-19 Surveillance Dashboard. https://nssac.bii.virginia.edu/covid-19/dashboard/

Google. COVID-19 community mobility reports. https://www.google.com/covid19/mobility/

Biocomplexity page for data and other resources related to COVID-19: https://covid19.biocomplexity.virginia.edu/

Questions?

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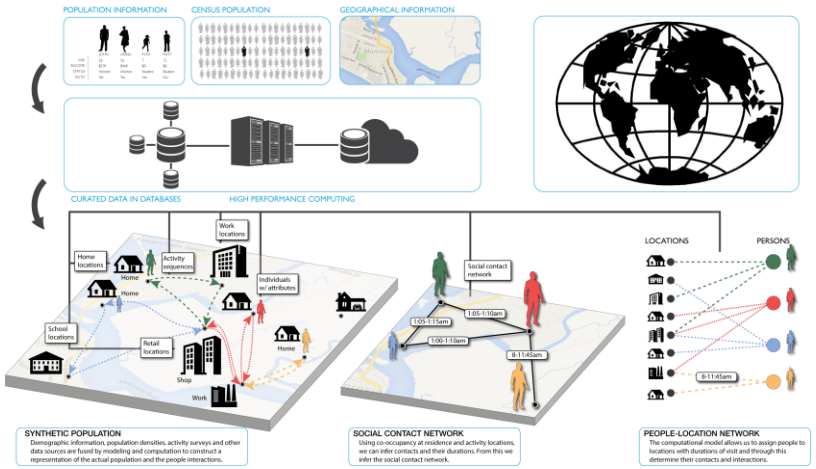
Supplemental Slides

Agent-based Model (ABM)

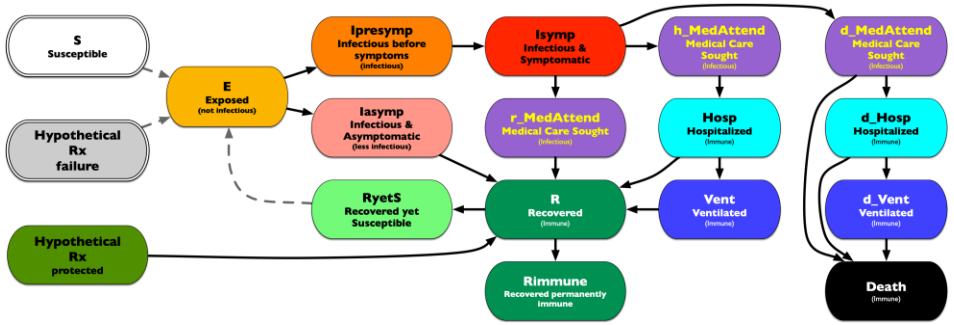
EpiHiper: Distributed network-based stochastic disease transmission simulations

- Assess the impact on transmission under different conditions
- Assess the impacts of contact tracing



Synthetic Population

- Census derived age and household structure
- Time-Use survey driven activities at appropriate locations



Detailed Disease Course of COVID-19

- Literature based probabilities of outcomes with appropriate delays
- Varying levels of infectiousness
- Hypothetical treatments for future developments